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ANNALS OF The Entomological Society of America

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Number 1

STUDIES ON THE MUSCULATORY SYSTEM AND MOUTH PARTS OF LAELAPS ECHIDNINUS BERL.*

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Some time ago, while working with rats containing the rat trypanosome, *T. lewisi*, the writer became interested in the small ectoparasitic mite *Laelaps echidninus* Berl. which is commonly associated with them. Since the literature on the internal anatomy of Gamasids is not voluminous, and is in general somewhat vague as to exact details, a careful study of mouth-parts and the musculatory system seemed desirable and yielded results which it seems desirable to place on record as a starting point for future work.

Of previous studies the most important is that of Michael, in 1892. Other important papers bearing on the problem are cited in the bibliography.

This work was undertaken by the writer while an assistant in the Department of Zoology and later of Entomology at the University of Minnesota. To Dr. W. A. Riley and Dr. R. N. Chapman he wishes to acknowledge indebtedness for facilities and for encouragement in carrying it out.

CAPITULUM, MOUTH-PARTS AND PHARYNX.

The Acarina in general show but little demarcation of head, thorax and abdomen, and in *Laelaps* no external trace of exact demarcation exists between the thorax and abdomen.

*Paper No. 982 of the Journal Series of the Minnesota Agricultural Experiment Station.

The head, or more properly the capitulum is, however, quite distinct, but differs markedly from the Hexapod head, being in the form of a more or less elongate cylindrical capsule attached to the ventro-cephalic surface of the thoracic region by a belt of non-chitinated tissue. It bears the mouth parts at its distal end, and by the action of certain muscles to be described later, it may be partially retracted within the body.

Its interior cavity is occupied dorsally by the large and strong sheaths of the retractible mandibles, Fig. 3 and Text Fig. 1 (ms). and ventrally by the complicated musculature of the sucking pharynx. (For ease of orientation, we shall assume the head to be held in a strictly prognathous position.)

The mouth parts, themselves, form a group of more or less lanciolate structures, with its long axis approximately collinear with that of the capitulum capsule itself.

Anteriorly, the mandible sheaths are fused in the middle line; posteriorly they are entirely separate from each other.

At their anterior ends, also, they become fused with the dorsal wall of the capitulum capsule, Figs. 3 and 5 (f), and Text Fig. 1, and in the same region, also, a stout bar of chitin extends from the ventral surface of each sheath to fuse with the ventral surface of the capitulum capsule, Figs. 3 and 5 (b), and Text Fig. 1.

Thus, from Text Fig. 1, particularly, it will be evident that at its anterior end, the tube forming the shell of the capitulum becomes divided into five "pigeon holes;" dorsally, the two mandible sheaths, laterally the two openings (stp), the stipes of the palpi, into which the scapes of the palpi are set, and ventrally the opening (m) through which the sucking pharynx opens. The rim of (m), together with the walls of the anterior part of the pharynx, forms the support for the lingula, maxilla, etc.

Dorsally, the capsule of the capitulum is prolonged anteriorly to form a long, flap-like epistome, Figs. 1 and 2 (ep) which partially surrounds and encloses the mouth-parts proper. There is no evidence that the epistomè is fused laterally with any of the mouth-parts as Banks mentions may be the case with some Acarina.

The mandibles, themselves, are three-jointed, chelate, and may be protruded from or withdrawn into the mandible sheaths, from whose anterior openings they project. This retraction is effected by the powerful muscles, Fig. 5 (mm), which have their origin on the dorsal wall of the thoracic region, and their insertion within the basal joint of the mandibles.

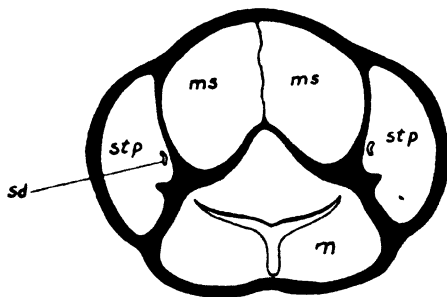
Between the bases of the mandibles, ventral to them, and having their support partially on the thickened anterior ends of the mandible sheaths, and partially on the anterior end of the dorsal wall of the pharynx, are the lanceolate vomer (v) and the lingula (l), Figs. 1, 2 and 3.

The vomer is, in this species, quite large and is grooved along the ventral surface. In the normal position, the dorsal ridge of the lingula lies in this groove. The lingula is also grooved on the ventral surface, Figs. 1, 2 and 3 (ge), the groove extending into the opening of the

pharynx, and in all probability, aiding in the flow of blood from the wound to the pharynx. The ventral surface of the lingula is continuous with the dorsal wall of the pharynx.

Throughout its length, the pharynx is in the form of a triangular tube, the walls of which may be buckled inward by the action of certain constrictor muscles, so that in section, it assumes the form of a three-pointed star. At the extreme anterior end, however, such constrictor muscles are absent, the tube remaining in the triangular form.

The dorsal wall, as we have said, merges with the ventral surface of the lingula, but the ventro-lateral walls spread outwards to approach the walls of the capitulum capsule, and fusing with them, form the support for the maxillæ, Figs. 1, 2 and 3 (max) and the two divisions of the hypostome (hy).



TEXT FIG. 1 Diagrammatic cross-section of distal end of capitulum capsule, at the base of the mouth parts

MS, Mandible sheath Stp Stipes of palpus M, Cavity of ligula maxillæ, etc Sd, salivary duct

These two hypostomal prolongations, together with the maxillæ, partially enclose the vomer and lingula on the ventral and lateral aspects, the enclosure being completed by the thin chitinous styli, Figs. 1, 2 and 3 (st). The styli have their support on the median surface of the stipes of the palpi

The latero-dorsal edge of each maxilla is slightly grooved and the ventro-median edge of the stylus, fitting into this groove, loosely locks the two structures together.

The salivary duct, Text Fig. 1 (sd), enters the interior cavity of each palpal stipes, but almost immediately crosses through the substance of the median wall, to enter the stylus, which it follows to the tip, opening to the outside through a small pore.

The palpus itself is five-jointed, Figs. 1, 2 and 3 (pal).

MUSCULATURE OF THE PHARYNX.

The peristaltic movement of the pharynx is brought about by the action of three sets of constrictor muscles, Figs. 2 and 3 (vl), (d) and four sets of extensors (vle), (de), (le).

The three sets of constrictors are alike in form, each muscle being attached at the ends to the pharynx as shown, and on contraction they cause the sides of the triangular tube to buckle inward along the middle line.

The two ventral sets (vl), are arranged directly opposite to each other, and number seven muscles each, while the dorsal sets (d) contain six muscles which are not arranged exactly opposite to those of the ventro-lateral sets.

The most anterior muscle of (d) coincides in position along the tube with the corresponding muscles of (vl), but more posteriorly, the positions of the muscles of (d) are progressively more and more posterior to those of (vl), so that the sixth muscle of (d) is midway between numbers six and seven of (vl). This asymmetry would seem to be inevitable when the placing of the extensors is considered, but it may incidentally result in a more even peristalsis.

The extensors are larger and more powerful than the constrictors. Two ventro-lateral sets, Figs. 2 and 3 (vle), have their origin on the ventro-lateral walls of the capitulum and their insertion on the ventro-lateral walls of the pharynx, thus working in opposition to the constrictors (vl).

In general, the positions of the individual muscles of (vle), alternate with those of (vl), but the whole assembly is placed more anteriorly, the eighth and most posterior muscle of (vle) being between numbers six and seven of (vl).

The individual muscles differ in complexity, numbers one and two being single, but from the third, counting toward the posterior end, each is double. (See Fig. 2). In some specimens the division was a little doubtful in the case of number three, but it seemed more often present than absent. There was some indication, too, that numbers seven and eight might be triple.

The two dorso-lateral sets of extensors, Fig. 3 (de) numbering five muscles each, have their insertion on the dorsal wall of the pharyngeal tube, but the individual muscles divide themselves into two groups on the matter of origin. The two anterior of each set have their origin on a thickened ridge on the ventral surface of the mandible sheath, Fig. 3 (rms), while the three posterior muscles originate from a ridge on the lateral wall of the capitulum, Fig. 2 (ltr). This ridge appears in cross-section in Fig. 2, but it curves obliquely in an antero-dorsal direction, and finally comes to a position on the lateral wall.

The insertions of these extensors (de) are between those of the constrictors (d) and are without regard to the positions of the constrictors (vl). The first and most anterior muscle is inserted midway between numbers one and two of the constrictors (d).

At the point of origin, these three posterior muscles of each set (de) appear to be fused, but they separate about half way between the origin and insertion; they are somewhat larger and more powerful than the two which have their insertion on the mandible sheaths.

Finally, there is a group of muscles, Fig. 3 (le) which has its origin on the ventral surface of the mandible sheaths at the posterior end, and

its insertion on the dorsal wall of the pharynx at its extreme anterior end, opposite the first and second extensors of the sets (vle).

In cross-section, this group divides itself into four sub-groups. The dorsal pair lie closely appressed in the groove between the mandible sheaths, and have their origin on the mandible sheaths at a point about opposite to the fifth ventro-lateral constrictor.

The two more ventral sub-groups have their insertion posterior to that of the dorsal pair and their origin about opposite to the sixth ventro-lateral constrictor.

The purpose of these muscles is not quite so obvious as in the case of the other constrictors and extensors, but it seems reasonable to suppose that they act in opposition to the first and second ventro-lateral extensors, since at that point on the pharyngeal tube, there are no typical dorsal extensors comparable to those situated more posteriorly.

It is interesting to note that the muscles of the sucking pharynx are non-striated.

MUSCULATURE OF THE THORACIC REGION.

Before going on to a discussion of the structures involved in the musculature of the thoracic region, it is necessary to give some explanation of Plates II and III.

In the case of Fig. 5, Plate II, that portion of the specimen posterior to the plane of division between the thoracic and abdominal regions has been entirely removed. The thoracic region and the capitulum have been divided by a median longitudinal section. Thus, the figure shows the interior of the left half of the thoracic region.

Figs. 6 to 18 of Plate III were obtained from the model of Fig. 5 by cutting the same into seven rather thick cross-sections, each of which, with the exception of that of Fig. 6, is viewed first from the posterior, and then from the anterior aspect. The posterior aspect of that of Fig. 6 is not repeated on Plate III, since it is shown at the extreme left of Fig. 5.

Thus, numbering the sections from posterior to anterior, Fig. 6 is the anterior face of Section 1. Figs 7 and 8 are the posterior and anterior faces respectively, of Section 2, and so on, until Figs. 17 and 18 are the posterior and anterior faces of Section 7, the most anterior of all the sections.

The muscles (mm) retracting the mandibles, and the muscles (lar) retracting the capitulum have been removed. These have their origin beneath the dorsal surface of Section 5, that is of Figs. 9 and 10, and continue along beneath the dorsal surface of the succeeding sections, as in Fig. 5.

NOMENCLATURE OF THE MUSCLES.

No satisfactory method of naming the muscles has been worked out, as the writer feels that any such system should have phylogeny and ontogeny as a basis, two subjects which have not been investigated in this study.

In order to distinguish them for purposes of description, numbers are used. Thus, all muscles labelled 4:1, 4:2, 4:3, etc., are concerned with the movement of the fourth leg. Similarly all muscles labelled 3:1, 3:2, 3:3, 3:4, etc., are concerned with the movement of the third leg, and so on. The few muscles not actuating a leg will be denoted by abbreviations of suitable names.

TYPES OF MUSCLES.

The muscles of the thoracic region of *L. echidninus* may be classified under 7 types, thus:

CLASS 1: With origin on the body wall.

Type (a). With insertion on the inner surface of a coxa.

Type (b). With insertion on the outer surface of a coxa.

Type (c). With insertion also on the body wall.

Type (d). With insertion within the capitulum or its associated structures.

CLASS 2: With origin on the endoskeletal frustule.

Type (a). With insertion on the inner surface of a coxa.

Type (b). With insertion on the outer surface of a coxa.

Type (c). With insertion on the body wall.

It might be noted, in passing, that the origin of the endoskeletal frustule was for some time a disputed point until Bernard, in 1896, showed that in the case of the *Galeodidae*, it is formed as a result of the expansion and fusion of lateral apodemes. It seems probable that the analogous structure in *L. echidninus* is homologous with this.

CENTRES OF ORIGIN FOR MUSCLES, ON THE DORSAL SURFACE OF THE THORACIC REGION.

Those muscles having their origin beneath the dorsal surface of the thoracic region and of the abdomen spring from fifteen well-defined centres, seven on each side and one above the frustule. In a sense, that above the frustule is also paired, but may be treated as a single centre. The paired lateral centres are situated as follows:

(Ce1). Anterior to the first coxa close to the median line.

(Ce2). Above the first coxa.

(Ce3). Above and between the first and second coxae.

(Ce4). Laterad of the frustule, and above the third coxa.

(Ce5). Laterad of the frustule, and above the fourth coxa.

(Ce6). Above the fourth coxa, somewhat laterally placed, posterior to (Ce5).

(Ce7). On the dorso-lateral surface of the abdomen, about one-half way between the abdomino-thoracic boundary and the anus.

The description of these muscles may be conveniently tabulated as follows, the numbers in the right hand column referring to additional notes which follow the tabulation:

TABULATION OF THORACIC MUSCLES.

No.	FIGURES	TYPE	ORIGIN	ATTACHMENT	REMARKS
4:1	6	1a	Ce7	Inner-posterior-lateral surface, Coxa 4	1
4:2	6	1a	Ce6	Anterior to 4:1	
4:3	7, 8	1b	Ce5	Outer surface, at apex; interior prolongation Coxa 4	
3:1	7, 8	1b	Ce5	Analogous position on Coxa 3	2
3:2	9	2b	On frustule, close to lateral edge	Anterior to 3:1	
3:3	9, 10	2b	Frustule, mesad of 3:4	Outer mesal surface, base of Coxa 3	3
3:4	7, 8	2b	Frustule, posterior to 3:2 and 3:3	Outer posterior face base of Coxa 3	
3:5	9, 10	1a	Ce4	Inner lateral surface Coxa 3	4
3:6	10, 11	2a	Frustule, anterior to 3:2 and 3:3	Inner anterior surface, Coxa 3	
2:1 2:2	10, 11, 12	2b	Frustule, anterior to 3:6	Outer posterior lateral face, Coxa 2	
2:3	11, 12	2b	Similar to 2:2	Laterad of 2:1, 2:2	
2:4	11, 12, 13, 14	2a	Frustule, anterior end	Inner mesal surface, Coxa 2	5
2:5	13, 14	1b	Ce3	Outer mesal side of foramen, Coxa 2	
2:6	13, 14	1a	Ce3 Laterad 2:5	Inner mesal surface, Coxa 2, posterior to 2:4	
2:7	13, 14	1a	Ce3 Laterad, 2:5 and 2:6	Inner lateral surface, Coxa 2	6
2:8	15, 16	2a	Ce3 Anterior to 2:6 and 2:7	Inner anterior surface, Coxa 2	
2:9	11, 12	1b	Lateral body wall	Outer lateral surface, Base Coxa 2	7

TABULATION OF THORACIC MUSCLES—Concluded.

NO.	FIGURES	TYPE	ORIGIN	ATTACHMENT	REMARKS
1:1	14, 15, 16	1b	Ce3 Anterior to 2:8	Outer posterior side rim of foramen of Coxa 1	
1:2	15, 16	1a	Ce3 Mesad of 1:1	Inner mesal surface of Coxa 1	
1:3	17, 18	1a	Ce2	Inner, antero-mesal surface, Coxa 1	
1:4	17, 18	1a	Ce2	Corresponding point to 1:3 on inner antero- lateral surface	
1:5	17, 18	1a	Ce1	Inner anterior surface, Coxa 1	8

REMARKS ON THORACIC MUSCLES TABULATED ABOVE.

NOTE 1. 4:1 is the only leg muscle having origin at Ce7.

NOTE 2. The muscle 3:1 is analogous to the muscle 4:3 in the case of the fourth leg.

NOTE 3. The muscle 3:3 has its origin on the frustule, immediately mesad of 3:2, and its insertion, apparently, at the base of Coxa 3, on the mesal surface. Winkler (1886) claimed that such a muscle has insertion on the ventral sclerite at the lateral margin. The writer is in doubt about this point. The majority of the sections examined seemed to show the insertion as figured, while some gave an indication of the insertion claimed by Winkler. The writer prefers to leave it a moot point.

NOTE 4. The muscle 3:5 is shown in a relaxed condition in the figures. It occurs uniformly in this condition in the sections.

NOTE 5. The muscle 2:4 has origin at the anterior end of the frustule, and passing in an antero-ventral direction passes mesad of the muscle 2:5 to its insertion on the inner mesal surface of Coxa 2. The writer can offer no explanation of such a remarkable path. It would seem that on contraction of 2:4, the muscle 2:5 would be pulled laterad. There is, of course, the possibility of an error in the interpretation of the sections, since there is a maze of cut muscle-ends in this region. However, a great deal of time was spent on these sections and the writer feels that such a mistake is unlikely.

NOTE 6. The muscle 2:7 would seem to work in direct opposition to 2:6.

NOTE 7. The muscle 2:9 is rather unusual, having its origin very low down on the lateral wall of the body, and its insertion on the base of

the coxa, on the lateral surface. Such a muscle was not found in the case of any other leg but the second.

NOTE 8. The muscle 1:5 is composed of three heavy and distinct fascia.

MUSCLES OF THE CAPITULUM.

The large mandibular retractor muscles, having their origin at the median centre, above the frustule, have already been mentioned.

The movements of the capitulum itself are controlled by six sets of muscles, three on each side of the body, and may be tabulated as follows:

DES.	FIGURES	ORIGIN	ATTACHMENT	REMARKS
1ar	5, 14, 15, 16	Just anterior to mandibular retractors	Anterio-lateral corners, rim, capitulum capsule	
1mr	5	Ce1, or just anterior to it	Extreme lateral portions	See note
1pr	5, 14, 15, 16	Ce3	Posterior-lateral corners, rim of capitulum capsule	

With regard to the second group (1mr) there is some doubt in the writer's mind as to the actual existence of such a group. In longitudinal sections, the muscles 1:5, Figs. 17 and 18, are very likely to be mistaken for muscles actuating the capitulum, especially as the actual points of insertion are very difficult to determine, even with an oil immersion lens. The same mistake may be made in cross-sections when the capitulum is in a partially retracted condition. Michael (1892) shows such muscles in Fig. 72 of his work on *Gamasids*, but it is to be noted that the figure does not commit itself to a definite insertion on the rim of the capsule. In fact, it shows exactly the same vagueness as appears in actual sections.

MUSCLES OF THE SPIRACLE.

A small group of fasciculæ, apparently only two, Figs. 5, 7 and 8 (spn) has its origin at the fifth lateral centre (Ce5) and its insertion on the body wall immediately anterior to the spiracle. It is thus of Type 1c, and is concerned with the movement of the spiracle. Whether it operates to open or to close it, could not be determined.

SUPPORT OF THE ENDOSKELETAL FRUSTULE.

The endoskeletal frustule, Figs. 5, 7, 8, 9 and 10 (esk) is attached to the dorsal wall of the body by supports of a more or less tendinous nature, Figs. 7, 8, 9, 10 and 11 (lfm), (dfm).

One pair, each of which is double, (dfm) extends upward from the dorsal surface of the frustule to the dorsal wall of the thoracic region. The other (lfm) extends laterally from a similar position to the dorso-lateral wall of the thoracic region.

SUMMARY.

1. It has been shown that the mouth-parts of *Laelaps echidninus* Berl. form a lanceolate and partially interlocked group at the distal end of the capitulum, of which group, the mandibles are retractible through the action of large muscles having origin far back on the dorsal wall of the thoracic region.

2. The pharynx itself was shown to be of the sucking type, having the form of a three-pointed star in cross-section.

3. It was also shown that the peristaltic movement of the pharynx is caused by the action of five sets of extensor muscles, and three sets of constrictor muscles, disposed along the length of the tube. The origin of these muscles varies, being upon the tube itself, upon the wall of the capitulum capsule, or upon a thickened ridge on the ventral surface of the mandible sheaths.

4. It was further shown in the case of the musculature of the legs, that the muscles could be divided up into a number of types on the basis of origin and insertion, and that they differed markedly from any arrangement found in insects, being, so to speak, "festooned" from the dorsal wall of the thoracic region, and from an endoskeletal frustule originating by the fusion of apodemes. Doubt was expressed as to the exact insertion of several of these muscles.

BIBLIOGRAPHY

- Banks, Nathan.** 1904. A Treatise on, and a Catalogue of the Acarina or Mites. *Proc. U. S. Nat. Mus.* XXVIII, No. 1382, 201 figs.
1915. The Acarina or Mites, a Review of the Order for the Use of Economic Entomologists. *U. S. Bur. Ent. Rpt.*, No. 108, 294 figs. (See pp. 84, 141.)
- Berlese, A.** 1875. Acarina Myriopoda et Scorpiones. Fasc. XXXIX, N. 1, Pl. 39, figs. 1-4.
- Bernard, H. M.** 1896. The Comparative Morphology of the Galeodidæ. *Lond. Trans. Linn. Soc.* Second Series, 6: 305-407.
- Hirst, Stanley.** 1914. On Three New Species of Gamasid Mites Found on Rats. *Bull. Ent. Res.* IV: 119-124, 4 figs.
1922. Mites Injurious to Domestic Animals. *Brit. Mus. Nat. Hist.* No. 13, pp. 1-105. (See p. 83.)
- MacLeod, J.** 1884. La Structure de L'intestin Anterieur des Arachnides. *Bull. Acad. Roy. d. Sci. Belg.*, 1884, pp. 377-396; 1 pl.
- Michael, A. D.** 1892. On the Variations in the Internal Anatomy of the Gamasinæ, Especially in that of the Genital Organs, and on Their Mode of Coition. *Trans. Linn. Soc. Lond.* 5: pp. 281-317, Pl. XXXII-XXXV.
- Oudemans, A. C.** 1912. (Paper inaccessible to writer) in *Ent. Ber. Nederland Ver.* III, 1912, p. 262.
- Winkler, W.** 1886. Das Herz der Acariden. *Arb. d. Zool. Inst. zu Wein.* Bd. VII, 1886, Heft 1, pp. 111-118; 1 pl.
1886. Anatomie der Gamasiden. *Arb. d. Zool. Inst. zu Wein.* Bd. VII, Heft 3, pp. 317-354; 5 plates.

EXPLANATION OF PLATES.

PLATE I.
(Figs. 1, 2, 3).*

Fig. 1. Capitulum from the ventral aspect.

MA, Mandible.

PAL, Palpus.

L, Lingula.

EP, Epistome.

ST, Stylus.

MAX, Maxilla.

HY, Hypostome.

STP, Stipes of Palpus.

Fig. 2. Capitulum from ventral aspect, with ventral surface removed, mouth parts cross-sectioned.

V, Vomer.

VLE, Vento-lateral extensor muscles of pharynx.

VL, Vento-lateral constrictor muscles of pharynx.

LTR, Lateral ridge for attachment of dorsal extensors.

Fig. 3. Capitulum from right side, with right and ventral surfaces removed.

B, Chitinous bar connecting mandible sheath to ventral wall of capitulum capsule.

LE, Longitudinal extensor muscles of pharynx.

MS, Mandible sheath.

F, Fusion of mandible sheath with capitulum capsule.

D, Dorsal constrictors of pharynx.

DE, Dorsal extensors of pharynx.

PLATE II.

Fig. 5. Interior view of left half of thoracic region.

C:1, C:2, C:3, C:4, Coxae.

T:1, T:2, T:3, T:4, Trochanters.

CE. 1, CE. 2, CE. 3, etc., Lateral centres of origin for muscles.

4:1, 4:2, 4:3, etc., Muscles actuating fourth leg.

3:1, 3:2, 3:3, etc., Muscles actuating third leg, and so on, for first and second legs.

MM, Retractor muscles of mandibles.

ESK, Endoskeletal frustule.

LFM, Dorso-lateral support of frustule.

SPM, Muscle-actuating spiracle.

SPI, Spiracle.

PVM, AVM, Small muscles connected to ventral sclerite.

LPR, Latero-posterior retractors of capitulum.

LMR, Latero-mesal retractors of capitulum.

LAR, Latero-anterior retractors of capitulum.

C, Capitulum capsule.

F, Fusion of mandible sheaths with capsule.

MS, Mandible sheaths.

B, Chitinous bar connecting mandible sheaths to capsule.

PLATE III.

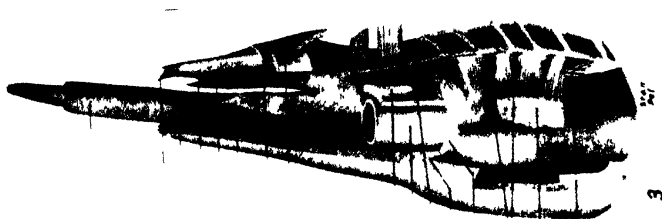
Figs. 6-18, incl. Posterior and anterior faces of thick sections cut from a model of the left half of the thoracic region, with certain muscles and portions of the capitulum removed.

(Letters used as designations same as for Plate II, Fig. 5.)

*Fig. 4 in series on plates removed to text as Text Fig. 1.—Ed.

Mouth Parts of Laclap
John Stanley

PLATE I



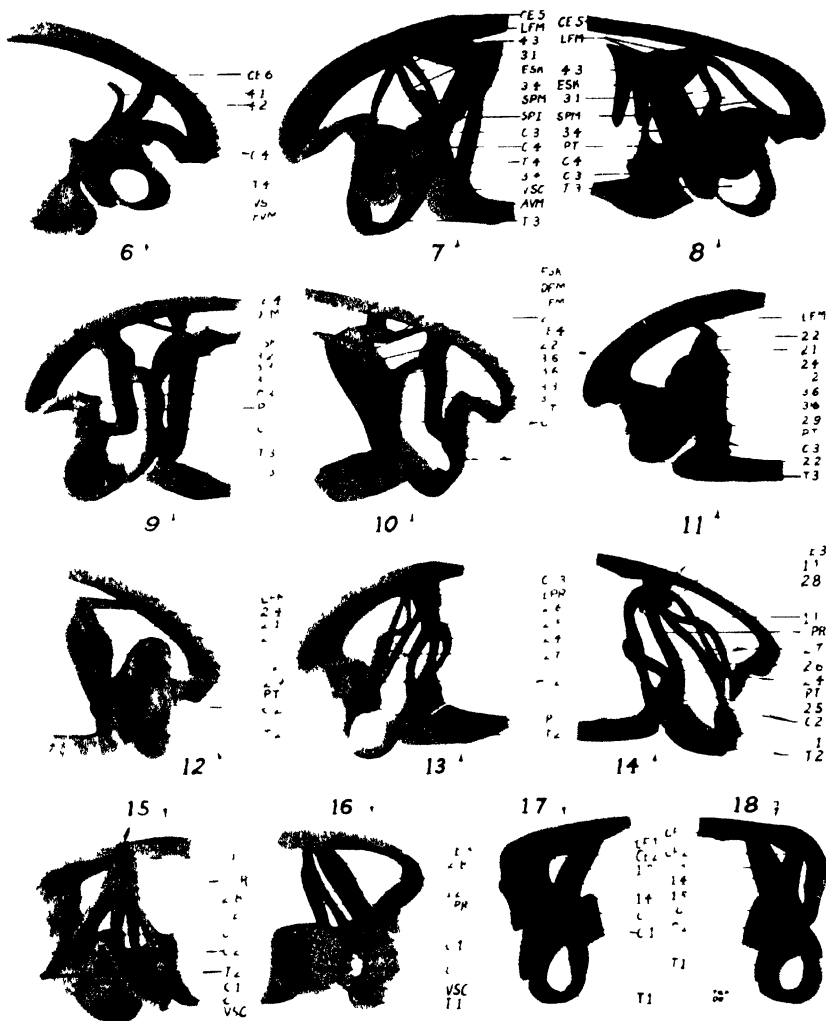
MA
-Y EP ST L V H MAX
EP MA V L ST MAX
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B MA LE F MS D - DE LE
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MA
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DORMANCY IN *REDUVIUS PERSONATUS* (LINNAEUS).*

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INTRODUCTION.

The subject of dormancy of *Reduvius personatus* (Linnaeus) first aroused the interest of the writer when, while rearing this species in connection with studies of the biology of the Reduviidæ, it was observed that this insect apparently ceased development during the winter months, even though kept in heated quarters and supplied with the same food which permitted its development at other seasons of the year. A survey of the literature showed that others had observed this phenomenon, but had not attempted to explain it. De Geer (1) stated that this species passed the winter as an engorged nymph, without taking food; that its body became thin and flat; and that at the return of warm weather it again became active and recommenced feeding. Also Poujade (2) recorded the fact that he kept a nymph which he collected in August, 1887, until it molted and became an adult in June, 1888, thus living for ten months without undergoing more than one molt, its final one. This insect remained torpid during the winter and took no food.

It seems quite likely that this phenomenon is not limited to this species alone, but may be found in other insects of the same ecological group. Thus the clothes moth, *Tinea pellionella* Linnaeus; the buffalo carpet beetle, *Anthrenus scrophulariæ* Linnaeus; and the meal worms, *Tenebrio molitor* Linnaeus and *T. obscurus* Fabricius, have all been observed to become more or less inactive during the winter, though conditions of food and temperature have been suitable for their development.

There is a further possibility of a connection between dormancy in these insects and that exhibited by out-of-door

*This paper represents the results of work done during the tenure of a National Research Fellowship in the Biological Sciences, under the direction of Dr. R. N. Chapman. The writer wishes to acknowledge his indebtedness, and to express his appreciation, both to the Board of Fellowships in the Biological Sciences of the National Research Council, and to Dr. Chapman.

insects which are subjected to low temperatures and lack of food during the winter months. Many of the latter group cease activity while temperature is still high and food still abundant, and when these insects are maintained at relatively high temperatures with food present during the winter months, they still persist in their dormancy.

MATERIAL AND METHODS.

The material necessary for the working of this problem was assembled during the summer of 1928 at Lawrence, Kansas. Adults of both sexes of *Reduvius* were collected at a light trap and paired. The insects were confined in small cartons, and were fed daily on house flies which had been caught in a net and disabled before being introduced. Eggs were removed daily, weighed, and placed in a salve box for hatching. Upon hatching each young nymph was isolated in a small metal salve box, five-eighths inch high by one and one-half inches in diameter. It was found desirable to line the bottom of each box with a tightly fitting wad of heavy, unglazed paper, which served to give the bugs a foothold, and also to absorb excess moisture from food and excrement. Later, in work involving humidity, three-quarters inch holes were punched in the lids, and these openings covered with coarse silk bolting cloth, so that the atmosphere inside the box could come into equilibrium readily with that of the cabinet in which it was placed.

The nymphs also were fed house flies, since there was a large supply available. However, after the active work at St. Paul was begun, on September 3, a change of food was made to the larvæ of *Tribolium confusum* Duval, the confused flour beetle, an insect which is being used a great deal in experimental work by Dr. R. N. Chapman and his students. This insect proved to be a very satisfactory food supply for *Reduvius*, since it could be reared in any numbers desired, and in a short time, on common flour. The greatest objection to their use was that occasionally they would crawl upon, and kill or cripple a molting *Reduvius*.

Two methods were used in keeping a record of the development of the insects. The dates of occurrence of the molts were recorded, as is usual in rearing work. However, a more definite picture of the course of development than could be obtained by this method alone was desired, and so resort was made to the method of weighing individual insects at intervals, in order to determine the nature of growth between molts. The weighing was done with a chemical balance, the insect being enclosed in a stoppered weighing bottle. Since the range in weight is from .0004 gram in the newly hatched nymph, to .1438 gram in the largest adult recorded, anything less sensitive than a chemical balance would be unsatisfactory. The determinations were made at intervals of from one to seven days, and from these data growth curves were plotted for comparative study.

LIFE HISTORY OF REDUVIUS.

The later part of this report will be clearer if a seasonal life history of *Reduvius* is given here. This insect may be found as an adult from May to September, at least in the vicinity of Lawrence, Kansas. It may be found in dusty and unused portions of dwellings, or may be collected at bright lights, to which it is attracted. The eggs are laid at this season of the year in dusty corners, and hatch after an incubation period of from 15 to 25 days, within the range of summer temperature at Lawrence. The nymphs occupy the same habitat as do the adults and feed on insects also, according to the writer's observations, although Fabre (3) considered that they fed on animal fat, since he found them in the bone room of a slaughter house. The nymph molts five times,

TABLE I
Oviposition and Incubation Record of One Pair of *Reduvius*,
by Days and by Ten-day Periods

DATE	NO. OF EGGS 10 DAY TOTAL	WT. OF EGGS 10 DAY AVERAGE PER EGG—g	LENGTH OF EGG STAGE 10-DAY AVERAGE	
5-24				Male collected
6 7				Female collected
6 8 to 6-17	63	000553	22 7	
6 18 to 6 27	57	000546	18 4	
6 28 to 7- 7	79	000523	15 7	
7 8 to 7-17	89	000530	15 5	
7 18 to 7 27	87	000514	15 8	
7 28 to 8 6	64	000526	16 1	
8 2				Male died
8 7				Female died
Total and Avs.	439	000531	17 3	

and at the fifth molt appears as a fully developed, winged adult. There is normally but one generation a year. It was because of the fact that I had observed what was apparently a dormant period during the nymphal life of this insect that I was attracted to this problem.

Oviposition and Incubation. Three pairs of adults only were assembled, and of these only one pair produced a large number of fertile eggs. The oviposition and incubation record of this pair is given in Table I, which probably includes the normal, complete adult life, since the female, when collected, was still soft of body, indicating recent molting.

Table I indicates that there are no abrupt changes in rate of egg production during adult life, since the differences observed in the ten-day totals are very likely due to seasonal variations in temperature. The differences in average weight per egg during the ten-day periods are also slight, although a general decrease in weight toward the end

of the oviposition period is indicated. The table also shows a progressive decrease in the length of the incubation period, very evidently correlated with seasonal temperature changes.

Early Growth: The growth of the first, second, and in a certain number of the group, the third instar, appeared to proceed without interruption. However, the variation in length of the first instar, from 11 to 65 days; and of the second instar, from 15 to 59 days, suggests the possibility of a short dormant period even in these early stages of development.

Appearance of Dormancy: The remainder of the insects in the third instar, together with others in the fifth, fourth and second instars, showed an almost complete cessation of development as winter approached, so that by the middle of November development had

TABLE II.

Number of Molts by Ten-day Periods of 159 Individuals of *Reduvius*, from Hatching, July 5-August 20, to November 16.

Date	No. of Molts	Date	No. of Molts
July 20-29	17	Sept. 18-27	60
July 30-Aug. 8	15	Sept 28-Oct. 7	66
Aug 9-18	26	Oct 8-17	40
Aug. 19-28	28	Oct. 18-27.	20
Aug 29-Sept. 7	38	Oct. 28-Nov. 6	8
Sept. 8-17	42	Nov. 7-16	3

apparently ceased. An idea of the slowing down of development may be obtained from a study of Table II, which gives the record of molts of the whole population by ten-days periods from hatching to November 16.

Since the hatching period of the insects included in Table II extended from July 5 to August 20, the maximum number of molts could not be expected until about a month after the last date of hatching. The maximum once attained, it would be expected that this number would be kept up if there were no interruption to development. However, a study of the table shows that as the season progressed the number of molts decreased strongly until in the last ten-day period recorded only 3 individuals out of 159 molted. At the end of the period recorded, after which the group was broken up for rearing under various conditions of temperature and humidity, there were 4 individuals in the fifth nymphal instar, 50 in the fourth, 101 in the third, and 4 in the second.

EXPERIMENTS.

Light on the nature and occurrence of the dormant period is thrown by the weight records, which, when plotted against time, take the form of growth curves. A series of these, representing insects kept throughout their development under room conditions, as a check, is shown in Figure 1.

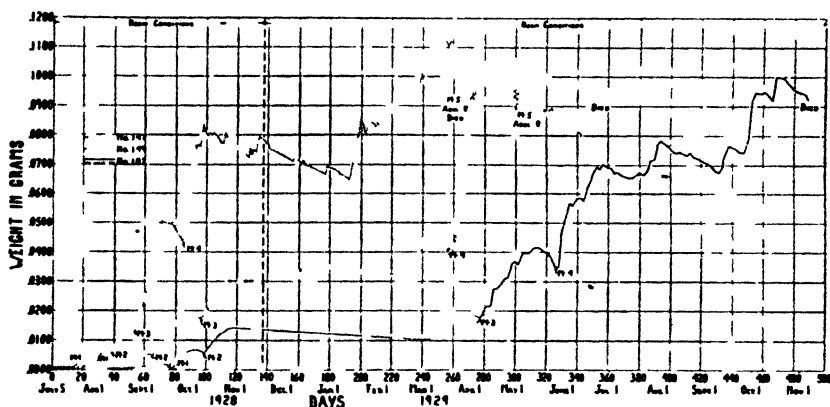


FIGURE 1 Growth of three individuals of *Reduvius personatus* at room conditions

In Figure 1, as in all other growth curves included in this report, weight on the vertical axis is plotted against time on the horizontal axis. Molts are indicated by the designations M-1, M-2, etc. Heavy lines, dashes and dots are used for weights actually determined. Light lines, dashes and dots are used for the portions of the curves where weight was not actually determined. These portions are exact with respect to the horizontal axis, but approximate with respect to the vertical axis.

Insect number 147 may be considered as a representative of the 4 insects which were in the fifth instar at the time of appearance of dormancy. The curve of this insect shows a relatively uninterrupted course of development, with interruptions only for molts, through the fourth instar and slightly beyond. However, a decided flattening of the growth curve, occurring soon after the fourth molt, shows that some hindrance to further development is operating.

The early part of the growth of number 149 may be considered as typical of the 50 insects which reached the fourth instar before dormancy appeared. In this case the early growth is less rapid, and the fourth molt is not made until the spring following hatching. Again there is a definite flattening of the curve of growth, indicating interruption.

Number 107 may be considered as typical of the 101 insects which reached only the third instar before dormancy appeared. Here the early growth is still slower, and the interruption to development occurs after the second molt, the third molt taking place after the dormant period.

These curves show a rather surprising variation in rate of growth in this species. Also, the occurrence of an interruption during the several periods of development is not what would be expected in inherent dormancy. That is, in all the commonly accepted cases of inherent dormancy, the dormancy is associated with a definite stage of development, and does not occur elsewhere in the life cycle. In fact, the occurrence of the dormancy in this case at a certain season of the year, without regard to the stage of development, strongly suggests the possibility of some seasonal factor being responsible for the inception of dormancy.

Growth of Similar Insects: At this point it is well to consider the growth records of other insects which may logically be expected to show development similar to that of *Reduvius*. For purposes of comparison the growth records of two other insects, *Sinea diadema* (Fabricius), and *Cimex lectularius* (Linnaeus), have been recorded and growth curves plotted. The former is of the same family as *Reduvius*, so may be considered as taxonomically similar, as well as similar in regard to food and method of feeding, though a field insect. The latter, the common bed bug, is a household insect, and may be considered as similar ecologically.

These curves show that the growth between molts, as in *Reduvius*, consists of a comparatively long period of rather rapid increase followed by a short period of decrease in weight preceding the molt. There is less individual variation than in *Reduvius*. The most important thing for our consideration, however, is that development from egg to adult is continuous, there being no flattening of the curve of growth previous to the

appearance of the adult at least. It should be explained here that the term "adult" is used to refer to the fully winged individual which appears after the last molt, and is not neces-

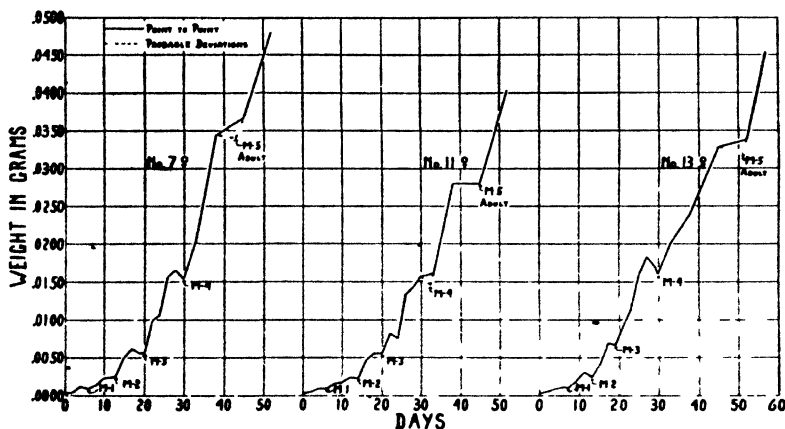


FIGURE 2. Growth of three female *Sinea diadema* from time of hatching to beyond final molt to adult, July 6 to August 27, 1928.

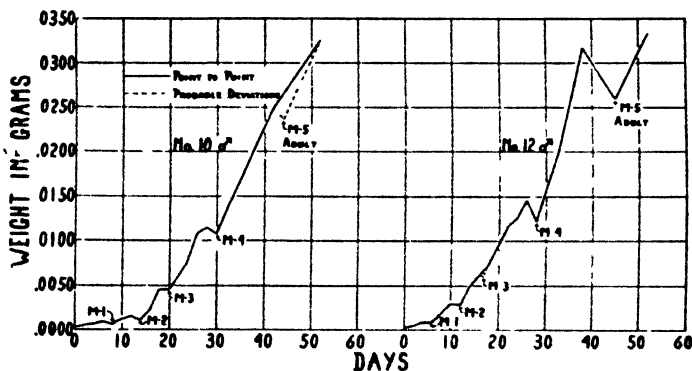


FIGURE 3. Growth of two male *Sinea diadema* from time of hatching to beyond final molt to adult, July 6 to August 27, 1928.

sarily limited to the sexually mature form. In this species there is apparently considerable growth after the final molt.

The curves of growth of the bed bug are quite different in appearance from those of the Reduviidæ, *Reduvius* and *Sinea*. The bed bug feeds only once for each stage of development, and after this meal, remains hidden until after the molt occurs.

Soon after the molt it is ready to feed again. While the growth curve of the bed bug does not show a continuous rise, nevertheless the general course of development is continuous.

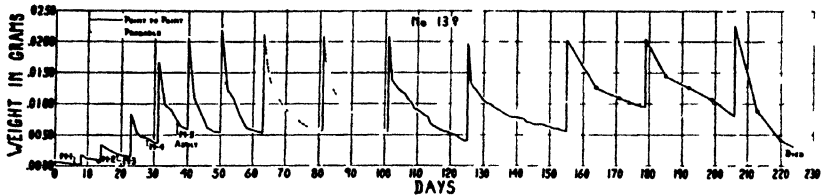


FIGURE 4. Growth of single female *Cimex lectularius* from hatching to death, June 6, 1928, to January 16, 1929.

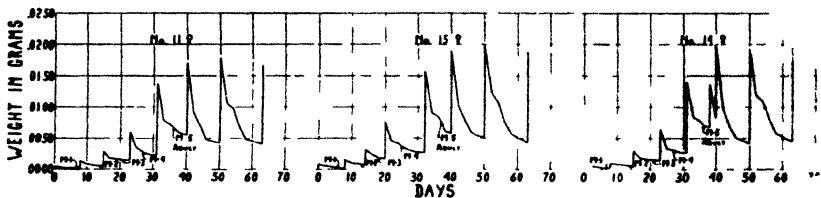


FIGURE 5. Growth of three female *Cimex lectularius* from hatching to beyond final molt to adult

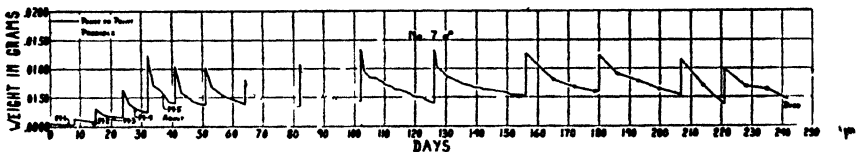


FIGURE 6. Growth of single male *Cimex lectularius* from hatching to death, June 5, 1928, to February 29, 1929.

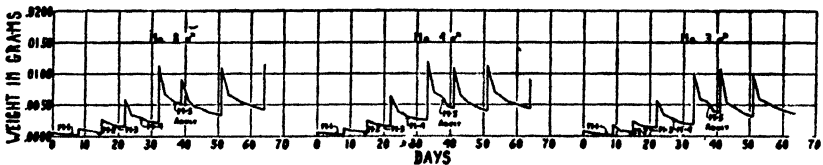


FIGURE 7. Growth of three male *Cimex lectularius* from hatching to beyond final molt to adult.

Thus, the essential thing shown by the growth curves of *Sinea diadema* and *Cimex lectularius* is that the cessation of growth observed in *Reduvius* is a developmental peculiarity common neither to the systematic, nor to the ecological groups to which *Reduvius* belongs.

Recovery From Dormancy under Various Combinations of Temperature and Humidity: Because of the indication of a possible seasonal influence in the dormancy of *Reduvius*, as shown in the molting records and growth curves, it was decided to determine the effect of various temperatures and humidities on the dormancy. Six combinations were possible for a part of the time at least. Two temperature and humidity control cabinets manufactured by the Carrier Engineering Corporation were maintained at 27° C., 75% relative humidity, and 27° C., 50% relative humidity respectively. A third cabinet without humidity control was held at 27° C. The intention was that this cabinet would be in equilibrium with the atmosphere of the room as far as humidity was concerned. However, in the determinations made it was found to vary from room humidity, 20-30% relative humidity, to as high as 50% relative humidity. However, the average was decidedly lower than that of the 50% Carrier cabinet, and it may be considered as forming the third and lowest of a series of three humidities all held at 27° C. A fourth cabinet was held at 32° C., and at 75% relative humidity. A fifth was held at 22° C., 75% relative humidity. Necessary repairs caused the interruption of the work in the last mentioned cabinet. A sixth group of insects was maintained at room conditions, where the temperature varied 2 or 3 degrees above and below 22° C., and the relative humidity from 20 to 30%.

The results of submitting third instar insects which had apparently become dormant at room conditions before November 19, to these various combinations of temperature and relative humidity, are shown in Table III.

Table III shows that the insects of the first four groups recovered from dormancy to the extent of molting in a comparatively short time after subjection to the changed conditions. Also the recovery appears to be in response to higher temperature, and not in response to higher humidity. This is best shown in the series of insects all maintained at 27° C., but at three different humidities, in which recovery takes place in all three after approximately the same length of time, 16.1, 18.1 and 15.5 days. Thus it would appear that the decrease in relative humidity which accompanies the advance of winter has nothing to do with the inception of dormancy in this case. Nor is it possible to conclude that dormancy became necessary

because temperature was not high enough to permit active development, since development did take place at the temperature at which dormancy appeared, previous to the appearance of dormancy. The most logical explanation of the results is that dormancy appeared as the result of some inherent condition, and was broken by the stimulus of higher temperature. Possibly dormancy would not have appeared during the third instar at the higher temperature, but the tendency to dormancy would nevertheless have been present. Since the experiment

TABLE III.

Recovery of Third Instar *Reduvius* which had Become Dormant at Room Conditions, When Subjected to Various Combinations of Temperature and Humidity.

CONDITIONS		No. of Insects	Av. No. Days Since Last Molt	Died	Molted	Av. No. Days to New Molt	Tot. Length of 3rd Inst. Av. No. Days
Temp	Rel. Hum.						
32° C.	75%	15	40.4	1	14	11.9	52.4
27° C.	75%	17	44.6	1	16	16.1	60.7
27° C.	50%	15	44.7	1 (Acc.)	14	18.1	62.8
27° C.	Uncontr.	15	42.7	0	15	15.5	58.1
22° C. (17 days only)	75%	19	35.2	0	4	3.7	39
32° C. (17 days previous in 22° C., 75% R. H.)	75%	15	59.6	1	14	10.5	70.1
Check. (Room conditions)		17	41.4	2 (Acc.)	15	117.6	159

involving insects maintained at 22° C., 75% relative humidity was interrupted after 17 days, the results here are inconclusive. Four out of 19 insects completed their development of the instar and molted in an average time of 3.7 days. Since the length of time necessary for the molt was so much shorter than at the higher temperatures it is considered that these individuals probably had not become completely dormant, and hence did not satisfy the conditions of the experiment. The remainder of these insects, when placed at 32° C., 75% relative humidity, molted in 10.5 days, showing little or no effect of the preceding 17 days at 22° C., 75% relative humidity in producing relief from dormancy. The remaining 17 insects, held at room con-

ditions as a check, did not make the third molt until after an average period of 117.6 days.

Similarly fourth instar insects which had become dormant at room conditions were subjected to combinations of different temperatures and humidities, in an attempt to discover the relation of these factors to dormancy. The results of these experiments are summarized in Table IV.

The results here are similar to those shown in Table III, in that those maintained at the higher temperatures all recovered

TABLE IV

Recovery of Fourth Instar *Reduvius* which had Become Dormant at Room Conditions, when Subjected to Various Combinations of Temperature and Humidity.

CONDITIONS		No of Insects	Av. No. Days Since Last Molt	Died	Molted	Av. No. Days to New Molt	Tot. Length of 4th Inst. Av. No. Days
Temp	Rel. Hum.						
32° C	75%	6	36 7	3	3	27 6	64 3
27° C	75%	10	37 4	2	8	27 7	65 1
27° C	50%	6	33 7	2	4	27 7	61 5
27° C	Uncontr	6	38 2	1	5	26 2	64 4
22° C (39 days only)	75%	13	18 5	0	2	33	51 5
Room Conditions (39 days previous at 22° C, 75% R. H.)		11	98 4	3	8	83 1	181 6
Room Conditions (Check)		10	52 6	1	9	123 9	176 5

and molted in approximately 27 days, while those kept at original conditions as a check did not recover until after having passed through an average dormant period of 123.9 days. Recovery and molting required longer than in the third instar. There is no indication in the results that recovery requires less time at 32° C. than at 27° C., though the numbers are so small that this may not be of significance. The death rate is higher than in the third instar, especially at the higher temperatures. This may be explained on the assumption that some of the fourth instar individuals are more completely dormant than others, so completely so that the stimulus of higher temperature fails to break their dormancy, and since high temperature and dormancy are incompatible, causes their death.

Growth of Fourth and Fifth Instar *Reduvius* at Various Combinations of Temperature and Humidity: After the recovery, under the influence of higher temperatures, of the greater number of insects which had become dormant at room conditions, a study of the growth of the fourth and fifth instars at various combinations of temperature and humidity, and of the occurrence of other dormant periods in the life cycle was made.

The data for the growth of the fourth instar are presented in Table V.

TABLE V.

Growth of Fourth Instar *Reduvius* at Various Combinations of Temperature and Humidity.

CONDITIONS		No. of Insects	Length of 3rd Instar. Days Av.	Died	Molted	Length of 4th Instar. Days Av.	Length of 3rd and 4th Instars
Temp.	Rel. Hum.						
32° C.....	75%	20	58.1	3	17	41.8	99.9
27° C.....	75%	18	59.6	1	17	28.8	88.4
27° C.....	50%	16	69.2	4 (Acc.)	12	32.7	101.8
27° C.....	Uncontr.	14	57.7	1	13	33.3	91
Room Cond. (A) (Check)	.....	12	158.1	3	9	65.2	223.3
Room Cond. (B) (Check)	.....	13	29.3	1 (Acc.)	12	171.5	200.7

Table V shows that at the higher temperature of 32° C. and 27° C. the development of *Reduvius* during the fourth instar proceeds without the intervention of a long dormant period at all of the conditions of humidity investigated. The length of time necessary for the growth of the instar was longer at 32° C. than at 27° C., and the death rate was higher at the higher temperature. Of those maintained at room conditions, those which had passed through the third instar in a comparatively short time (Group B), entered a dormant period during the fourth instar; while those which had already passed through a long dormant period in the third instar (Group A), completed the development of the fourth instar without undergoing a long dormant period.

From these results we may conclude that the stimulation of higher temperature is effective in the growth of the fourth,

as well as in recovery from dormancy in the third and fourth instars; and that at lower temperatures dormancy during the third instar eliminates the necessity for dormancy during the fourth instar.

Table VI shows that fifth instar insects maintained at the higher temperatures of 32° C. and 27° C. were unable to complete the growth of this instar without the intervention of a dormant period. Of those maintained at 32° C., 8 out of 14 were killed accidentally, and the other 6 had died previously. Of those maintained at 27° C., 75% relative humidity, 10 out of 17 died

TABLE VI.
Growth of Fifth Instar *Reduvius* at Various Combinations of
Temperature and Humidity.

CONDITIONS		No of Insects	Length of 3rd Days Av.	Length of 4th Days Av.	Length 1-4 Days Av.	Died	Molted	Length of 5th Days Av.	Length 1-5 Days Av.	Av. Max. Weight Grams
Temp.	R. H.									
32° C	75%	14	51 2	41 9	151.1	14	0	.		
27° C	75%	17	51 7	40 1	145.3	10	7	143.3	288.6	0926
27° C	50%	16	62 2	34 2	158.3	10	6	129.5	287.8	0913
27° C	25%	13	57 6	36 5	156 5	5	8	87.9	244.4	1102
Room Cond (Check-A)		7	21	41 7	105.7	4	3	190.3	296	1116
Room Cond. (Check-B)		16	32 6	163	244.7	3	13	56.7	301 5	1034
Room Cond. (Check-C)		6	167 6	64 2	286 5	6	0		478 4 (Inc)	0940

and the remainder molted to the adult after an average period of 143.3 days. Of those at 27° C., 50% relative humidity, 10 out of 16 died, and the remaining 6 transformed after an average period of 129.5 days. Those maintained at 27° C., 25% relative humidity had a death rate of 5 out of 13, the remaining 8 transforming after an average period of 87.9 days. This group completed its development in the shortest time, with the lowest death rate, and the greatest maximum weight attained, of any of the three groups maintained at the same temperature, but different humidities. This indicates that low relative humidity is favorable to successful dormancy in this insect. The high death rate in this and other groups maintained at high temperature is again an indication of the incompatibility of high temperature with dormancy.

Of the group maintained at original conditions of 22° C., room humidity, those which had completed their earlier development without a long dormant period (Group A), became dormant during the fifth instar; of those which had passed through a dormant period in the fourth instar (Group B), 12 out of 16 passed through the fifth instar without a long dormant period, while the remaining 4 again became dormant during the fifth instar, 3 dying before transformation; those which had passed through a dormant period in the third instar, but not in the fourth (Group C), again entered a long dormant period in the fifth instar. Thus, the only group that escaped a dormant period in the fifth instar was the group which had just recovered from a dormant period in the fourth instar, and even some of these also became dormant in the fifth instar.

These results give further evidence to show that dormancy in *Reduvius* is inherent in nature, rather than induced by environmental conditions of temperature and humidity, since dormancy occurred in the fifth instar at the same conditions of temperature and humidity which allowed active development in the third and fourth instars. There is a very decided indication that dormancy is more intense in the later stages of development, being most intense during the fifth instar.

Growth Curves: To give a more complete picture of the occurrence of dormant periods in the life cycles of insects reared under various conditions of temperature and humidity, growth curves of representative insects are given.

Figure 1 is of the development of three insects kept at room conditions as a check. These insects became dormant at three different points in their development, one in the fifth, one in the fourth, and one in the third instar. Number 147 became dormant during the fifth instar, lost weight during the winter, recovered slowly during late winter and early spring, and finally molted to the adult on the first of April. Number 149 became dormant in the fourth instar, made the fourth molt in the spring, and then very quickly completed the growth of the fifth instar and molted to the adult. In this case, then, dormancy during the fourth instar made dormancy during the fifth instar unnecessary. Number 107 spent the winter in dormant condition in the third instar, recovered and made the third molt in the spring, completed the growth of the fourth instar without interruption, but entered a second dormant

period during the fifth instar. The life of this insect, ended without reaching the adult stage on November 6. In this case dormancy during the third instar replaced dormancy in the fourth instar, but did not eliminate dormancy during the fifth instar. It is interesting to note that in this insect dormancy occurred during the summer months.

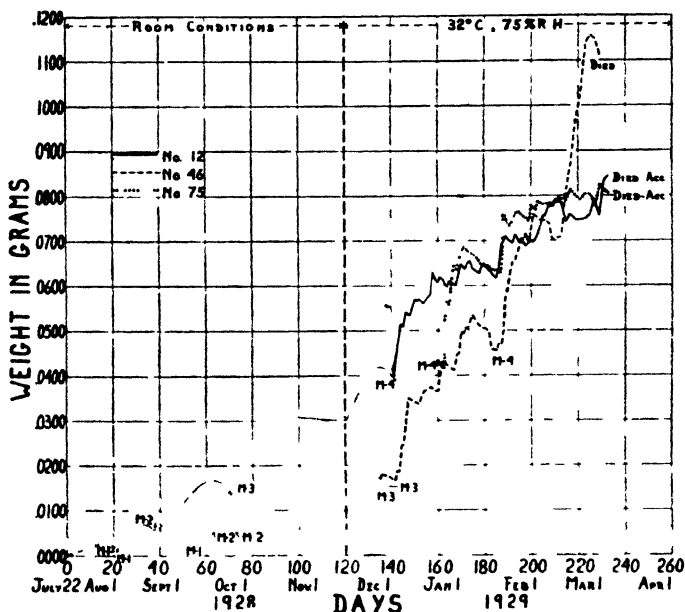


FIGURE 8. Growth of three individuals of *Reduvius* which had become dormant at room conditions and were later subjected to conditions of 32° C., 75% relative humidity.

Number 12, in the fourth instar at the time of change of conditions, recovered from dormancy under the stimulus of higher temperature, molted to the fifth instar, and passed nearly a hundred days in the fifth instar before being killed accidentally. Numbers 46 and 75 had become dormant in the third instar, and were stimulated by higher temperature to make the third molt, and also to complete the development of the fourth instar, but apparently could not complete the development of the fifth instar without passing through a dormant period. The whole group being maintained at these conditions was killed accidentally.

Number 91, in the fourth instar at the beginning of the experiment, recovered and molted to the fifth instar, but spent

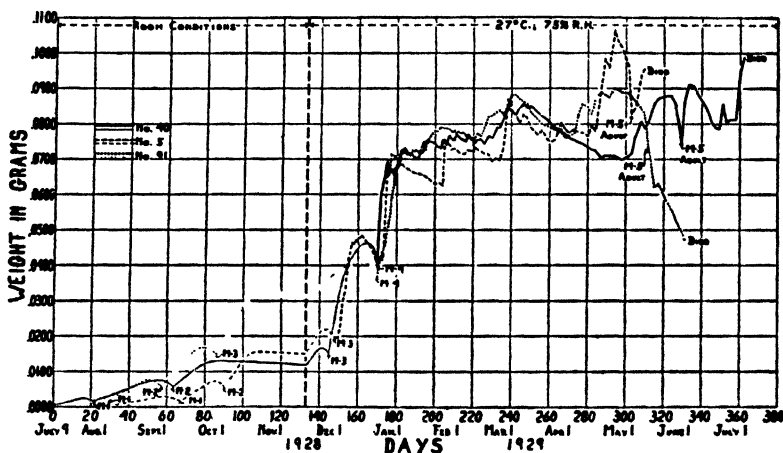


FIGURE 9. Growth of three individuals of *Reduvius* which had become dormant at room conditions, and were later subjected to conditions of 27° C., 75% relative humidity.

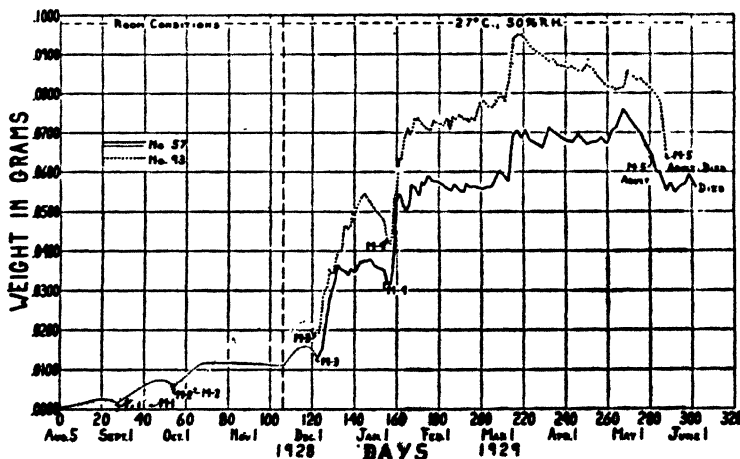


FIGURE 10. Growth of two individuals of *Reduvius* which had become dormant at room conditions, and were later subjected to conditions of 27° C., 50% relative humidity.

a comparatively long time in the fifth instar before molting to the adult. Numbers 5 and 40 were in the third instar at the beginning of the experiment, recovered and molted to the fourth

instar, completed the growth of the fourth instar without interruption, but became dormant during the fifth instar, finally molting to the adult.

In the case of the two insects shown in the above figure, recovery and molting took place soon after subjection to the conditions of the experiment, the growth of the fourth instar was completed without interruption, but dormancy appeared in the fifth instar.

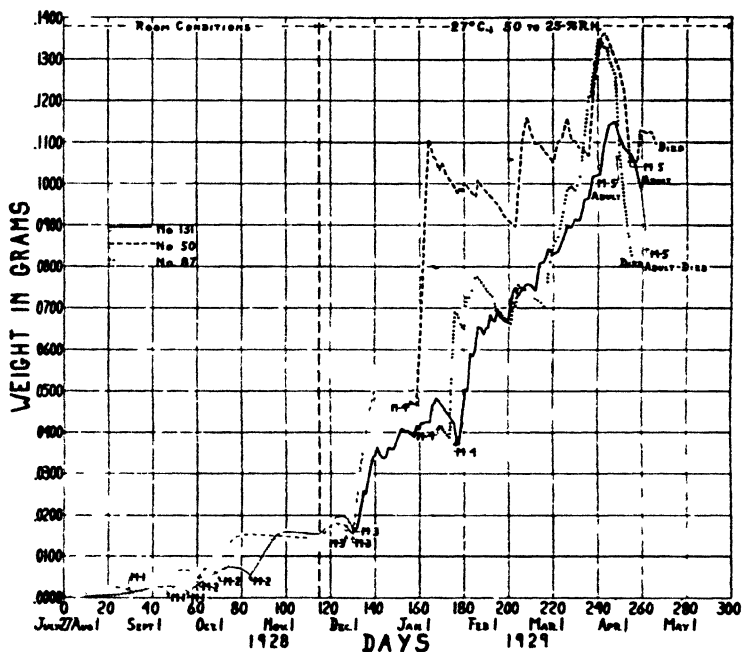


FIGURE 11. Growth of three individuals of *Reduvius* which had become dormant at room conditions, and were later subjected to conditions of $27^{\circ}\text{C}.$, 50 to 25—% relative humidity.

The insects shown in Figure 11, all in the third instar at the time of subjection to experimental conditions, recovered from dormancy and made the third molt, completed the growth of the fourth instar without interruption, but passed through a short dormant period in the fifth instar before molting to the adult. The development of insects under these conditions differed from development at the same temperature, but higher relative humidity, in that dormancy during the fifth instar did not last so long, and the maximum weight attained was greater.

DISCUSSION OF RESULTS

A study of the growth of the early stages of *Reduvius*, before the appearance of dormancy, shows that there is a great deal of variation in rate of development. This variation, since it can not be accounted for by the conditions of rearing, must be considered as due to inherent individual variation in rate of growth, probably connected with variation in rate of metabolism. This variation in rate of development seems very significant in relation to the irregular appearance of dormancy later in the life cycle. In fact, it seems quite likely that the extreme length of the early instars may be due to the appearance of a short dormant period.

The cessation of active development indicated by the decline in number of molts shown in Table II, and by the growth curves in Figure 1, is a phenomenon of primary interest in this study. There are two possible explanations for this cessation: first, that it is due to some environmental factor; second, that it is due to an inherent dormancy appearing at several places in the life cycle.

The seasonal factors most likely to be of importance are food, temperature and humidity. In this case food can not be of importance, since the insects were supplied continually with the same food which allowed active development earlier in the year. Temperature, also, varied only slightly from that which had allowed active development. The humidity of the atmosphere, however, varied a great deal, declining as winter approached, in general correlation with the appearance of dormancy.

If the cessation in development is due to inherent dormancy, the dormancy is one that appears irregularly at several points in the live cycle, which is unusual in insects. However, Calvert (4), in studying the growth of the dragon fly, *Nannothemis bella* (Uhler), found that two of the insects with which he was working transformed to the adult stage after having spent two winters in a dormant condition, while a third individual transformed only after having spent three winters in dormancy. These insects were furnished food continually, and were not subjected to extreme variations in temperature (89° to 50° F.). Dr. Calvert says of their condition: "From January to April, 1926, the *bella* larvæ were

very sluggish, this feature being more marked in numbers 56 and 58 than in the other two. Responses of number 56 to touch stimuli on March 14 were very slow and slight, but even in this individual the degree of sluggishness varied from week to week." It may be, then, that the irregular appearance of dormancy is more common in nature than is known. The individual variation in rate of development observed in the earlier stages of *Reduvius* indicates the possibility, at least, of an individual variation in the stage at which dormancy appears.

The experiments involving recovery of third and fourth instar insects which had become dormant at room conditions, when subjected to various combination of temperature and humidity, indicate that humidity could not have been the determining factor in the inception of dormancy, since recovery takes place in response to higher temperatures, rather than to higher humidity. Neither can we conclude that the lower temperature at which dormancy appeared was responsible for its inception, since it has already been shown that active development did take place at that temperature. We are led, then, to the conclusion that dormancy in *Reduvius* is inherent, but that it may be broken during the third and fourth instars by the stimulation of higher temperature. Jucci (5) and others have shown that submersion in dilute acid, friction, extreme temperatures, etc., are effective in producing the hatching of dormant silk worm eggs, and to the writer this seems to be a similar phenomenon.

Growth of the fourth instar proceeded without the interruption of dormancy at the higher temperatures of 32° and 27° C., but at 22° C. those insects which had not passed through a dormant period in the third instar became dormant in the fourth instar. Dormancy during the third instar, however, made dormancy during the fourth instar unnecessary.

The growth of the fifth instar was not completed without interruption even at the higher temperatures. All of the insects which had not passed through a dormant period in the fourth instar, and even some of these also, became dormant during the fifth instar, regardless of temperature. Thus the stimulus of higher temperature, which caused the breaking up of dormancy in the third and fourth instars, and caused the uninterrupted growth of the fourth instar, was not effective in producing the continuous development of the fifth instar.

This is rather direct evidence that dormancy in *Reduvius* is inherent in nature. It also shows that dormancy in the fifth instar is more intense than in the third and fourth instars. The data on the growth of the fifth instar also give rather decided evidence to the effect that low humidity is favorable to successful dormancy in this insect.

Several theories attempting to explain the fundamental nature of inherent dormancy have been advanced. Of these, Roubaud's (6) theory of uremic intoxication appears to fit the observed phenomena better than any other. According to Roubaud, the dormancy is due to the accumulation of unexcreted urates, which have a toxic effect and prevent further development. Roubaud found that certain species recovered from dormancy when subjected to stimuli, such as heat, pricking, bleeding, etc., while others did not. He concluded that the dormancy was less intense in the former cases, and more intense in the latter. Roubaud gave the conditions of successful dormancy as low temperature or low humidity, since either retards the rate of metabolism, but allows the excretion of urates to continue. In the above results we see that low humidity was more successful than higher humidities in relieving dormancy, and that the death rate was high in dormant insects at high temperatures and humidities. The results of this paper can not be considered to substantiate Roubaud's theory, but the agreement in the points mentioned is worthy of note.

CONCLUSIONS

1. There is a distinct individual variation in rate of development in *Reduvius*, evident throughout the whole course of nymphal development.
2. This species may enter into a state of prolonged dormancy during the third, fourth or fifth nymphal instars, and probably into shorter periods of dormancy in the first and second instars.
3. The study of the growth of other insects, *Sinea diadema* (Fabricius) and *Cimex lectularius* (Linnaeus), shows that this dormancy is characteristic of neither the taxonomic, nor the ecological groups to which *Reduvius* belongs.
4. The dormancy is of the obligatory type, that is, produced as a result of some inherent, physiological condition, and not induced by unfavorable external conditions of development.

5. The insect, when dormant, is subject to the influence of environmental factors. Dormancy of the third and fourth instars is broken by the stimulus of higher temperatures, though that of the fifth instar is not. Dormancy of the fifth instar (also that of the third and fourth instars, possibly) is completed more successfully (shorter, with lower death rate, and with higher maximum weight attained) at low, than at high humidity.

6. Dormancy is progressively more intense in the later stages of nymphal development.

7. While the results obtained by no means completely substantiate Roubaud's theory of uremic intoxication, the assumption of the truth of this theory permits the explanation of the phenomena observed.

LITERATURE CITED.

- (1) De Geer, Carl. Mémoires pour servir à l'Histoire des Insectes, III. 1773. Stockholm.
- (2) Pujade, G. A. Ann. Soc. Ent. Fr., 1888. P. XXXI.
- (3) Fabre, J. H. Le Reduve a Masque. Souvenirs Entomologique, Huitieme Serie, 1903; 6: 88-105.
- (4) Calvert, P. P. Different rates of growth among animals with special reference to the Odonata. Proc. Am. Philos. Soc., 1929; 48: 227-274.
- (5) Jucci, C. Il comportamento ereditario di un carattere fisiologico nei bachi da seta: il bivoltinismo. Bol. Soc. Ent. Ital., 1926; 58: 56-63.
- (6) Roubaud, E. Études sur le sommeil d'hiver pré-imaginal des Muscides. Bull. Biol. de Fr. et de Belg., 1922; 56: 455-544.

ADDITIONAL NOTES ON THE NATURAL ENEMIES OF THE IRIS BORER, *MACRONOCTUA ONUSTA* GROTE (LEPIDOPTERA).

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In an earlier paper² the writer reported on the natural enemies found attacking the Iris borer, *Macronoctua onusta* Grote, at Madison, Wisconsin, in 1928. The studies were continued in 1929, and the following notes are intended to constitute a sequel to the former. An unusually heavy infestation of several years standing furnished the opportunities for these studies. Data have been gathered which offer a basis for comparing the development of the infestation of 1929 with that of 1928, and suggest the influence natural enemies may have on the fluctuation of the population.

The Iris at the station occupies nine nursery rows of about forty meters each in length. The occasional removal of a few plants and the cultivation of the soil between the rows constitute the chief disturbances by man in recent years. Each season the dead and discolored remains of the Iris plants have not been removed or destroyed, providing conditions in this respect favorable for the development of the infestations.

By May 15, the mines of the young borers were numerous in the leaves of the Iris. It was again noted that the mines were most numerous in the leaves of plants belonging to the Apogon group. Early in June, the borers had nearly all extended their burrows well down between the ensheathing lower halves of the leaves; and from all appearances the infestation was developing on a parallel with that of 1928. Later in the season however, it became apparent that the population was being reduced in numbers, and that the borers were not nearly so numerous as they had been at a similar period in 1928.

¹These data were gathered while the writer was employed as Field Entomologist for the Wisconsin Department of Agriculture and Markets.

²Breakey, E. P. Notes on the Natural Enemies of the Iris Borer, *Macronoctua onusta* Grote (Lepidoptera). Ann. Ent. Soc. America, XXII, pp. 459-464, 1929.

Experience had taught that larval development would be nearing completion early in August. On August 4, collections were again made with the hope of securing a census of the natural enemies which would be attacking *M. onusta* at this stage. Only by persistent effort were the needed one hundred specimens secured. A comparison of the infestations of the two seasons at this period can be obtained from the following: In 1928, a section from a row of Japanese Iris about five meters in length yielded one hundred seventy-two specimens from the earth near the plants, while one year later one hundred specimens were obtained from the entire nursery only by persistent effort. It is regretted that so little has been learned of the enemies which attack the caterpillars earlier in life.

It was quite generally held that the summer of 1929 had been drier than usual. The writer had noted that instead of finding an accumulation of wet excrement in the burrows of the caterpillars, as was to be expected, the usual experience was to find the contents of the burrow quite thoroughly dried out. This, together with the dry condition of the soil encountered while making collections, suggested that a comparison of the rainfall for the two seasons might be helpful in accounting for the decrease in the population of *M. onusta* and the apparent change in the constituency of the parasitism. The following summary is based on the Monthly Meteorological Summaries issued by the local office of the U. S. Weather Bureau.

RAINFALL IN INCHES.

	May	June	July	August
Normal	3 85	3 76	3 88	3 21
1928	-0 88	+2 57	-1 24	+1 48
1929	-2 54	+0 59	+4 14	-2 34

+ Excess.

- Deficiency.

It would be difficult to evaluate the effect rainfall, or the lack of it, may have had on the development of the infestation or on the success of the various parasites. The last seventeen days of July, 1929 were without rainfall, with one notable

exception. On July 23, 24, 25 and 26, 4.93 inches of water fell. This was followed by a deficiency in August of 2.34 inches. Conditions were apparently ideal for periods of drought. This is a case for atmometry and cannot be adequately explained without such data. Such conditions of dryness would not contribute to the success of species with habits such as those of *Muscina stabulans* Fall. and *Myiospila mediatubunda* Fab., while species with habits such as those of *Masicera senilis* Mg. would be only indirectly affected.

One hundred caterpillars of *M. onusta* were collected and accounted for, using the same procedure as in 1928. Of this number, eight were destroyed by parasitic Diptera, six by parasitic Hymenoptera, and one by a species of parasitic fungus. It will be noted that Diptera were apparently responsible for about the same degree of parasitism as in 1928. Evidence was obtained which indicates that Diptera may have been responsible for an even greater percentage of parasitism. The shrunken remains of twelve caterpillars were found having the appearance of those recently abandoned by parasite maggots. Only one of these figures in the above data however, as it was the only one having the puparium of the fly associated with it in an unquestionable manner. Since no Hymenoptera or fungi were found attacking the caterpillars in 1928, it is interesting to find them occupying such an important place in the parasitism of *M. onusta* in 1929.

The following notes are presented for the purpose of suggesting the extent to which each species may be considered a natural enemy of *M. onusta*.

HYMENOPTERA¹

The first Hymenoptera appeared in the cages on August 29 and the last on August 31. In each instance the host had been destroyed in the pupal stage. The following species issued from the chrysalids of *Macronoctua*: *Amblyteles laetus* (Brullé), *A. rubicundus* (Cress.) (Ichneumonidæ) and *Psychophagus omnivorus* (Walk.) (Pteromalidæ).

¹The writer wishes to thank Messrs R. A. Cushman and A. B. Gahan, of the U. S. National Museum, for their services in determining the identity of the Hymenoptera.

Amblyteles laetus (Brullé).

This solitary parasite was apparently the most important of the Hymenopterous enemies of *M. onusta* in 1929. Adults of this insect issued from three percent of the specimens under observation. The chrysalis of the host was used in lieu of a cocoon in which to undergo transformation. This species is known to be a parasite of *Papaipema* spp., and the writer has secured it from pupæ of *Pyrausta ainsliei* Hein., the smart weed borer, at Madison. The pupæ of *Pyrausta* were of the overwintering generation. It is evident that *A. laetus* has two generations a year and can use *Macronoctua* as the summer host.

Amblyteles rubicundus (Cress.)

One specimen of this species issued from a chrysalis of the host. From all appearances it is very similar in its habits to *A. laetus*.

Psychophagus omnivorus (Walk.)

Two pupæ of the host were destroyed by this multiple parasite, sixteen specimens issuing from one and thirty from the other. This species was also an important enemy of *Achatodes zea* (Harris), the spindle worm, at Madison in 1929.

DIPTERA.⁴

The first Diptera appeared in the cages on August 24. Later in the season, when carefully removing the contents of the cages preparing to put them away for the winter, three puparia from which flies had not yet emerged were found in the sand. These were given suitable care and on April 26, 1930 two small flies made their appearance. The following species were attacking *Macronoctua* in 1929: *Masicera senilis* Mg. (Muscidæ) and *Sarcophaga helici* Tns. (Sarcophagidæ).

Masicera senilis Mg.

This fly was the most important parasite of *Macronoctua* at Madison in 1929, destroying five percent of the caterpillars under observation. The interesting habits of this parasite have been discussed by the writer in the earlier report.

⁴The writer is indebted to Dr. J. M. Aldrich, of the U. S. National Museum, for determining the Diptera.

Sarcophaga helioides Tns.

Two specimens of this fly emerged on April 26, 1930. Dr. Aldrich states in correspondence, "This is a species which sometimes attacks living insects, but in many instances deposits its maggots upon dead ones; so it has quite a diversity of habit and seems not to be particular about the species of insect, being able to develop in almost anything."

FUNGI

Among the caterpillars collected was one which had the appearance of a well preserved mummy. It was cold, stiff and firm to pressure. Sensing that it had not died from ordinary causes it was preserved for future observation. On the following day its body was completely covered with a mat of white hyphæ. Later it was sent to Prof. Roland Thaxter for examination. The fungus proved to be still viable and he reported that it was the typical *Beauveria* (*Sporotrichum*) *globulifera* Speg. This fungus attacks a great variety of insects and is being used by the Gypsy Moth Laboratory against the satin moth.

SUMMARY OF KNOWN PARASITES OF
MACRONOCTUA ONUSTA GROTE.

DIPTERA.

Muscina stabulans Fall.
Muscina assimilis Fall.
Myiophila medilabunda Fab.
Sarcophaga cimbicis Tns.
Sarcophaga latisterna Park.
Sarcophaga helioides Tns.
Masicera senilis Mg.

HYMENOPTERA.

Apanteles militaris Walsh.*
Amblyteles jucundus (Brullé)*
Amblyteles laetus (Brullé).
Amblyteles rubicundus (Cress.)*
Amblyteles brevicinctus (Say).
Psychophagus omnivorus (Walk.)

FUNGI.

Beauveria (*Sporotrichum*) *globulifera* Speg.

*Reported by H. F. Dietz from Indiana.

*Reported by E. N. Cory from Maryland. This species' presence at Madison was established when a specimen issued from a chrysalis of *Achatodes zeae* (Harris) on July 14, 1929.

THE POST-EMBRYOLOGICAL DEVELOPMENT OF THE DIGESTIVE SYSTEM IN HOMALEDRA SABALELLA CHAMBERS*†

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*A Thesis submitted to the faculty of the Graduate School of Cornell University in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

†The preparation of material and preliminary studies were made in the College of Agriculture of the University of Florida at Gainesville. The final work and preparation of the manuscript was completed in the Department of Entomology at Cornell University, Ithaca, New York. The writer wishes to express deep appreciation and sincere thanks to Dr. O. A. Johannsen, of Cornell University, for the many suggestions, valuable criticisms and interest offered during the progress of the work.

INTRODUCTION

The development of the digestive system of insects has been intensively studied by many investigators. Modern workers are apparently agreed upon certain fundamental structures and changes that appear to persist in certain groups. Corroboration of these points, however, has been shown in but relatively few orders. In view of the fact that no recent investigations upon the morphological changes that occur in Lepidoptera have been undertaken and with the purpose of studying certain points of anatomy and metamorphosis that have been recently demonstrated in certain other orders, the present study was undertaken.

HISTORICAL.

Among the first observers of metamorphosis in Lepidoptera were Malpighi (1669) and Swammerdam (1685), the latter using *Pieris brassicae* and *Vanessa urticae* for his observations. Réaumur (1734), Lyonet (1763), and Herold (1815) contributed observations on the external changes of larva to adult. It was not, however, until Weismann (1864) proved the presence of imaginal discs in Diptera and showed that parts of the larval body underwent disintegration or histolysis, that post-embryological studies began.

The morphological changes in the digestive canal have been more intensively studied in Diptera, Hymenoptera and Coleoptera than in Lepidoptera. The principal workers were: in Diptera, Weismann (1864), Ganin (1876), Kowalevsky (1887), Van Rees (1888), Hurst (1890), Miall and Hammond (1892), Vaney (1902), Pérez (1902, 1910), Thompson (1905), Hewitt (1907), and Snodgrass (1924); in Hymenoptera, Seurat (1869), Karawaiew (1897), Berlese (1901), Pércz (1911), and Tiegs (1922); in Coleoptera, Rengel (1896), Möbüz (1897), Deegener (1900), Berlese (1900-1, 1913), Poyarkoff (1910), and Beal (1927).

Other orders that have been studied are Odonata, Needham (1897); Collembola, Folsom and Wells (1906); Neuroptera, Matheson (1912); and Thysanoptera, Müller (1927).

Anatomical studies on larvæ of Lepidoptera have been numerous since the famous treatise by Lyonet (1762). Bordas (1911) contributed the most recent and comparative study of the gross and histological structure of the digestive tract and malpighian tubes of some twenty-nine larvæ selected from the families Nymphulidæ, Sphingidæ, Arctiidæ, Cossidæ, Liparidæ, Saturnidæ, Cymalophoridæ, Notodontidæ, Noctuidæ, and Tortricidæ.

Post-embryological changes in the digestive tract of Lepidoptera are confined to the writings of Verson (1905) on *Bombyx mori* and Deegener (1908) on *Malacosma castrensis*. Cholodkovsky (1887) studied the histolysis and histogenesis of the muscle tissue in *Tinea* and Metalnikoff (1908) studied the phagocytic destruction of the muscles of the alimentary canal in the wax moth, *Galleria mellonella*. Samson (1908) working on *Heterogenea limacodes* Hufn. (Limacodidae) and Hufnagel (1912) on *Hyponomenta padella* (Tineidae) studied the metamorphosis of the Malpighian tubes. The latter investigations on the Malpighian tubes were continued by Ikeda (1913) and later by Ito (1926) working with *Bombyx mori* L. in Japan.

BIOLOGY AND LIFE HISTORY OF THE SPECIES.

The larvae of *Homaledra sabalella* Chambers (Order Lepidoptera, Family Cosmopterygidae) live as skeletonizers on the leaves of certain palms and palmettos. The species is commonly known as the palm-leaf skeletonizer or palmetto-leaf miner. In the United States it is confined to the states of Georgia, Florida, Louisiana, and Texas. It is also reported from the following islands of the West Indies: Cuba, Porto Rico, Santo Domingo, and Haiti. The biology and life history of this form has been carefully studied by Creighton (1929).

Eggs are laid on the dried, twisted tips of the palm leaflets or on the "inter-leafing husk" at the base of the leaflet, (Creighton, 1929). On emerging the larvæ spin a silken web on the leaf and live beneath this. Frass from the leaf and excrement from the body are piled on top of this web. Six definite instars have been observed with the average length of time in each instar as follows: 1st, 12.66 days; 2nd, 8.43 days; 3rd, 8.59 days; 4th, 6.78 days; 5th, 5.72 days; and 6th, 11.54 days. During the last instar the larva spins a heavy silken cocoon next to the leaf surface. This is lined with a very fine layer of closely woven silk to which the cremaster of the pupa is attached.

The larvæ remains dormant for one to three days before pupation. The pupal period may vary from ten to twenty-two days depending upon humidity and temperature conditions. As the specimens for the present study were all reared under artificial conditions the environmental factors were fairly constant and the pupal period extended from a minimum of seventeen days to a maximum of twenty days. The adults mate readily in large test tubes or glass jars. They live normally from two to three days to ten to twelve days and do not feed at any time either in nature or under artificial conditions.

TECHNIQUE.

Mature larvae were collected from palm leaves and placed in individual petri dishes with a small portion of the palm frond.

The exact time of pupation was observed through the glass or by removal of the cover. Prepupae were also removed from the silk web of the cocoon and allowed to pupate in the open. As the normal cocoon is not completely closed at one end, it was easily unraveled from that point. Pupae were then transferred to small stender dishes and allowed to develop until the respective time for their fixation. Many duplicates were fixed for each period.

All specimens were killed and fixed in hot Bouin's solution (Picric acid, saturated aqueous solution 75 c.c. formalin, 25 c.c.; glacial acetic acid, 4 c.c.), Kingsbury and Johannsen, 1927:8). Certain of the late larval and early pupal stages were embedded in paraffin but the majority were double embedded in celloidin. Material remained in 4 and 8 percent celloidin over periods of not less than 2 weeks to a maximum of 2 months. As the pupa is heavily chitinized it was always necessary to prick or remove portions of the cuticle in order to insure infiltration.

All sections, both longitudinal and cross, were cut in serial order 7.5 microns in thickness. The majority were stained with Delafield's Haematoxylin and counter stained with a 2 percent alcoholic solution of Congo Red. Certain of the larvæ were stained with Iron Haematoxylin and counter stained with Congo Red.

In the late larval and prepupal periods specimens were fixed every hour. Pupae were selected in the act of pupation and at 2 hour intervals afterwards, up to the 30th hour. After 30 hours specimens were fixed just at eclosion and at intervals during their normal life period (10-12 days). The adults as well as the larvæ were selected from field collected material as well as from laboratory raised specimens. All the specimens used in the present study were collected, reared, and fixed at Gainesville, Florida, where the species occurs throughout the year.

The majority of the pupæ were selected during late fall to early spring, but some were reared in the summer.

DIGESTIVE SYSTEM OF THE MATURE LARVA.

Larva of *Homaledra sabalella* Chambers of the same age vary slightly in size under normal conditions. Creighton (1929) gives the mean or average length of 50 larvae immediately after eclosion as 1.53 mm. with a mean deviation of $\pm .1008$ mm. In the present study only normal mature larvae in an active feeding state were used. Greater variation in size exists in this stage because of modifications in food and other factors that affect the larval period. The average mature larva measured 16.2 mm. in length from cephalic to caudal end. As the digestive system (Figs. 1 and 2) is a straight tubular structure extending between these points, the measurements,

accounting for slight variations in each individual, may be taken as follows: 1.1 mm. from the oral opening to the junction of the oesophagus and proventriculus, 1.3 mm. from the cephalic end of the proventriculus to the caudal end of the cardiac valve, 10 mm. from the cardiac valve to the pyloric valve, 1.8 mm. from the pyloric valve to the ileo-colic valve, 1.3 mm. as the length of the colon and .8 mm. the length of the rectum.

Fore Intestine.

Buccal Cavity. The buccal cavity or mouth is that area bordered anteriorly by the inner surfaces of the mouthparts in a typical mandibulate larva such as *Homaledra*, and extending caudad to the tubular pharynx. The cavity of the mouth measures 47 microns in length with a width varying from 34 microns at the median and widest point to 23 microns at the posterior end where it narrows perceptibly to become the pharynx.

The intima or innermost lining of the buccal cavity is a relatively thin chitinous layer lying over a narrow epithelial stratum in which a few scattered nuclei can be observed. The epithelial layer is thickest on the anterior, dorsal surface (9 microns) and narrows to a faint streak at the posterior end. The intima, however, is thinner anteriorly and widens posteriorly to form a lining of rather uniform width throughout the remaining region of the fore-intestine. The superior surface of the buccal intima is modified along its anterior two thirds to form delicate spines about 9 microns in length. These project backwards in the mouth. The lower surface of the cavity is smooth, but the upper is thrown into delicate wave-like folds along its entire length.

A band of longitudinal muscles, about 6 microns in width, lie exterior to a rather distinct basement membrane that surrounds the epithelial stratum. Several large circular muscles are situated just before the opening of the pharynx. A thin peritoneal membrane surrounds the muscular layer. Large dilator muscles are attached to the wall at the junction of the buccal and pharyngeal cavity.

Pharynx. The pharynx in most insects is not a definitely delimited area, but is commonly applied to a region between the mouth and oesophagus (Comstock, 1925:109). Haseman (1910:283) considers its caudal boundary in *Psychoda alternata* as marked by the posterior margin of the supra-oesophageal ganglion. The anterior margin of this ganglion marks the end of the pharynx in *Homaledra*.

The pharynx (Figs. 1 and 2) is slightly infundibular in shape, tapering from 15 microns at the buccal opening to 17 microns at the oesophageal aperture. The chitinous intima, continued from the buccal region, is slightly thickened through its anterior half and lies flat on an epithelial layer of flattened to ovoid cells, each with a definite oval nucleus. Bordas (1911:220) describes two zones in the chitinous intima of the anterior region of the pharynx in the larva of *Lo Irene*: "une région interne, hyaline; transparente, compacte et non colorable par les

reactifs, et une zone profonde a structure finement striée, et se continuant, presque sans ligne de démarcation, avec le cytoplasme sous-jacent." The present study appears to agree with this, but as the intima rarely exceeds 5 microns in thickness, the line of differentiation is not always clear. Continuous with this area, but lying caudad on the median lateral walls of the pharynx, the chitinous layer is thrown into ridges or rows, (9-12) which in longitudinal section appear to overlap posteriorly (Fig. 3). Heavy bristle-like projections from the intima line the overlapping margins and extend inwards. The superior surface is composed of rows of chitinous plates (19 microns long, 7 microns wide) with undulate margin bearing delicate hair-like bristles projecting caudad (Fig. 4). Verson (1905:534) describes the cuticula in the pharynx of *Bombyx mori* as especially thickened and armed with sharp teeth ("spitze Zähnen").

The epithelial layer of the pharynx consists of irregularly placed rather prominent oval to flattened cells, varying in diameter from 9 to 11 microns on the lateral and inferior surface to 13 to 15 microns on the superior with large circular nuclei (4 to 6 microns). The nuclear walls are distinct, as is also the cell wall in most preparations. The cells are scattered, some only connected by a faint strand of the epithelial tissue, other embedded in a deeper granular stratum. The basement membrane is clearly defined as it takes the stain more readily than the granular stratum which it surrounds, (Fig. 3, b. m.).

The anterior one third of the pharynx is surrounded by strong dilator muscles. Lying closely compressed to the basement membrane of the pharyngeal epithelium is a poorly developed layer of longitudinal muscle tissue, quite difficult to distinguish in many sections. The outer circular muscles are well developed and form a firm, almost continuous sheath about the entire tube, (Fig. 5, c. m.). In this stage (active larval) all the muscles show a normal striated condition. A peritoneal membrane surrounds the muscular layer and can be distinguished along the outer margin of the muscle bundles.

Oesophagus. The anterior portion of the oesophageal intima is smooth and flat. It begins at the cephalic margin of the supra-oesophageal ganglion and passes posteriorly over a deeply cleft and folded caudal region to the surface of the cardiac valve, and thence directly over the inner wall of the proventriculus. As the anterior region is directly caudad of the spines and chitinous plates of the pharyngeal wall, the oesophagus may be readily distinguished from the pharynx by the clefts and folds of its posterior wall, its thickened chitinous intima, its large and definitely outlined epithelial cells and the modifications in its muscular structure, (Fig. 6, oes.).

The epithelial cells in the anterior part are flattened, average 28 microns in length by 9 microns wide, with long oval nuclei 13 microns long. The cytoplasm is slightly granular to vacuolated with the chromatin in the nuclei staining as dark granules. The intima and epithelial layer are thrown into folds in the posterior region. In this region the epithelial cells gradually become larger, definitely cuboidal in shape, the largest measuring 38 microns long by 19 microns wide with

a circular nucleus 6 microns in diameter. The cells are densely vacuolated, the nucleus granular, and a rather large nucleolus is visible. A very definite sheath of longitudinal muscle tissue lies next to the basement membrane with a prominent continuous layer of circular muscles exterior to it. The peritoneal membrane can be distinguished at points along the course. The lumen, which has narrowed slightly between the oesophageal folds, widens beyond them to form the cavity of the proventriculus or crop, (Fig. 6, prov.).

Proventriculus. The proventriculus in the mature larva of *Homaledra* is formed by a widening of the posterior region of the oesophagus and a reduction in the normal structure of the wall to form a thin walled sack or reservoir. The contents of this chamber in a normal feeding larva appears to be in practically the same physical condition as in the fore part of the ventriculus.

Many investigators have studied the proventriculus or fore-stomach in other insect forms. It is also known in the literature as the "masticating stomach," and "Kaumagen" of the German workers. In *Lepisma* it is a spherical gizzard provided with six teeth; in the *Gryllidae* there are six folds that form a valve between the crop and proventriculus. It is especially well developed in many carnivorous and wood boring *Coleoptera*, where it is muscular, lined within with chitin and usually provided with teeth, brushes or plate-like structures or folds. Beal (1927) describes such a complicated thickening of processes in *Petyogenes* as originating from secretions of the epithelial cells. The proventriculus is also found in certain *Mecoptera*, *Odonata*, *Isoptera*, and *Hymenoptera*, (Imms, 1925:98, 99). In the honey bee it is a narrow valvular region between the honey sac and ventriculus (Snodgrass, 1925:156-158); in the *Diptera* it is also reduced to a valve.

The proventriculus in *Homaledra* offers no special structure of importance, (Fig. 5, prov.). The walls are thin and the chitinous intima slightly less in thickness than over the oesophagus proper, (Fig. 7). The epithelial layer is very narrow and often quite indistinct with an occasional flattened and elongated nucleus with dense chromatic granules. The basement membrane stains distinctly. Longitudinal muscles form a narrow outer sheath and are strengthened by circular muscles at regular intervals. Both lie within the peritoneum, which like the basement membrane stains clearly, and is quite visible in places.

The wall of the proventriculus extends posteriorly for 1.2 mm. and then forms a narrow fold extending anteriorly (.4 mm.) in the lumen to form the cardiac or oesophageal valve (Fig. 6, card. v.). Bordas (1911) found a similar valve in all the larvæ of *Lepidoptera* that he examined: *Cnethocampa*, *Carpocapsa*, *Pleretes*, *Vanessa*, *Sphinx*, *Spilosoma*, *Pygaera*, *Cossus*, *Stauropus*, *Ascherontia* and others. Verson (1905:534, 535) described a cardiac valve in *Bombyx mori*. Other writers have shown its existence in several species of *Diptera*, *Hymenoptera*, *Coleoptera*, *Orthoptera*, *Neuroptera*, and *Thysanura* (*Lepisma*).

At the junction of the cardiac valve with the wall of the ventriculus a triangular muscular area is formed with several annular muscles in

the center, (Fig. 8). A sheath of thin muscle fibers with an outer peritoneal covering extends over this area and continues over the wall of the ventriculus. No definite muscle fibers can be detected between the thin lamellæ of intima and flatly compressed multinucleated epithelial layer that compose the cardiac valve, except in the fold of the distal border, which is slightly enlarged. At least 3 to 4 annular muscles are found here. Numerous small flattened nuclei with very small chromatic granules line both walls of the epithelial stratum, (Fig. 6). These cells will later form the histoblastic cells of the oesophageal ring. There is no indication of any of the blood sinuses as reported by Imms (1907:301) in Dipterous larvæ.

Mid-Intestine.

The ventriculus or stomach is a straight tubular organ from 9 to 10.5 mm. in length, and under normal conditions of feeding shows a diameter of 1 to 1.5 mm. As the stage of feeding and digestion determines the exact shape, normal modifications will occur at all times, (Figs. 1 and 2).

Peritrophic Membrane. A conspicuous peritrophic membrane begins at the basal region of the cardiac valve and forms a membranous tube within the ventricular wall, (Fig. 6, p. m.). It is somewhat separated from the epithelial cells and surrounds partly digested and undigested food materials. The cell nuclei near the base of the cardiac valve are densely chromatic and the cytoplasm somewhat glandular in character. Some sections show definite glandular cells along the caudal border of the valve with granular chromatic nuclei and fibrous vacuolated cytoplasm. Probably the peritrophic membrane is secreted continuously from these cells as it is the only point where attachment is made. This conforms with the findings of Bordas (1911:229-232) in the larva of *Io Irene* and other Lepidoptera larvæ as well as with the works of certain other writers. Among those that believe the origin to be from specialized glandular or germinal cells near the anterior end of the mid-intestine are: Van Gehuchten in *Ptychoptera contaminata* (1890), Balbiani in *Chironomus* (1890), Miall and Hammond in *Chironomus* (1900), Hasemann in *Psychoda* (1910), and others.

Another type of peritrophic membrane has been described for *Aeschna* by Voinov (1898) and by Trappmann (1923) and by Snodgrass (1925) in the honey bee. In this the membrane is formed by a delimitation of the inner or free margin of the cells lining the mid-intestine (Imms, 1925:101). It is a non-chitinous structure quite different from that found in Lepidopterous larvæ.

Ventriculus. The wall of the mid-intestine or ventriculus consists principally of a broad band of tall columnar epithelial cells resting on a basement membrane or tunica propria. The muscle layer is thin but complete, (Fig. 9). Lying next to the basement membrane are the closely set fibers of circular muscles with an outer sheath of thin longitudinal muscles containing many nuclei. The nuclei occur regularly along the length of the tube.

The enteric epithelial cells are somewhat compressed but show considerable regularity. Cells in the anterior third measure 58.3 microns in height with a widest diameter of 11.3 microns; cells in the median area measure 67.7 microns in height with a diameter of 18.8 microns and those in the posterior third measure 48.9 microns in height and 9.4 microns in diameter. Normally the cells are narrower at the base and expanded in the median or distal region, (Figs. 6, 10, 11, 12). The nuclei are oval to circular in shape and vary in length from 5.6 microns to 11.3 microns with a diameter from 3.8 microns to 5.6 microns. They lie in the lower third to median region of the cell and contain fine chromatic granules and a nucleus which stains distinctly in the preparations. The epithelial cells of the anterior region of the mid-gut possess vacuoles within a rather reticulate, coarsely granular cytoplasm, (Fig. 10). The cells of the median (Fig. 11) and posterior region (Fig. 12) are more densely granular or finely vacuolate. The cytoplasm of the cells in the extreme posterior area contain an abundance of chromatic granules and stain deeper than those in the forward portions. Van Gehuchten (1890) in Dipterous larva showed secreting or glandular cells in the anterior part of the stomach and absorbent cells in the middle and posterior portion. Oertel (1928) described anterior and posterior chromatic cells in the mid-intestine of the honey bee. In *Homaledra* secretion is probably more abundant from the anterior half of the ventricular epithelium, but may be found at intervals along the entire stratum.

At the base of the epithelial cells are small oval to pyramidal shaped cells resting flatly on the basement membrane, with dark circular nuclei, (Figs. 10 and 11, hist. c.). In the anterior and median region these cells are usually single and very small, but placed at close intervals along the basement membrane. In the posterior region of the epithelium of a mature larva, these cells are arranged in small groups, (Fig. 12, hist. c.). Such cells are more commonly known as replacement cells, but have been described as epithelial buds, cells nests, Kryptes, Drüsenkrypten, Drüsen, nidi, etc. They have been found in many other insects: in *Tenebrio* (Coleoptera) by Frenzel (1885), in the Cockroach by Miall and Denny (1886), in *Cryptops* by Balbiani (1890), in the Odonata by Needham (1897), in *Nasonia* (Hymenoptera) by Tiegs (1922), in the California Locust by Tietz (1923) and others.

The inner or free surface of the epithelial stratum is marked by a distinct striated hem (Imms, 1925:100) or border varying from 3.8 microns to 9 microns in width (Fig. 12, s. b.). Lying between this and the peritrophic membrane is a finely granular substance, supposedly secreted from the underlying epithelial cells. This is more abundant in the posterior third of the ventriculus especially in the region of the pyloric valve.

Hind-Intestine.

The beginning of the hind-intestine (Figs. 1 and 2, malp. t.) is generally marked in insects by the insertion of the Malpighian tubes, (Imms, 1925:102). This region is readily distinguished in *Homaledra*,

externally, by means of a shallow groove or furrow and internally by a well developed pyloric valve bearing certain densely chromatic, typical histo-blastic cells. The entire tube is divided into three rather well marked regions: the ileum or small intestine, which consists of an anterior and posterior portion: the colon, or large intestine: and the rectum. In an average mature larva the dissected ileum measures 1.8 mm. in length, the colon when not distended 1.3 mm. and the rectum .8 mm., width varying from 1 to .8 mm. The muscular coat of the ileum separates it distinctly from the other regions. Verson (1905:553-556) describes three somewhat similar divisions in the larva of *Bombyx mori*. Bordas (1911:244-247) shows two enlargements in the posterior intestine of the larva of *Io Irene*, *Phalera bucephala*, and *Cnelocampa processionea* (Lepidoptera), but does not differentiate the regions.

The mid-intestinal epithelium ends abruptly, but a narrow wall continues and forms a fold which tends to decrease the diameter of the lumen (Fig. 13, py. v.). Immediately beyond this fold, or valve, the tissue expands to form a smooth walled tube, the ileum. The anterior surface of the fold which constitutes the pyloric valve, possesses a very flat, highly chromatic, multi-nuclear layer of epithelium. This continues to the margin of the valve, where it joins a group of larger but similar densely stained cells on the posterior side of the apex (Fig. 14, hist. c.). Adjacent to these cells are others more elongate, highly vacuolate with granular, oval nuclei. The first are definite histo-blastic cells, whereas, the latter are glandular in character. Together they constitute the anterior or frontal wall of the ileum (Fig. 13, il.).

Extending from the outer edge of the pyloric valve is a definite peritrophic membrane, which continues through the lumen of the ileum. Whether this chitinous structure is a continuation of that from the mid-intestine or a production of the cells at the point of its apparent attachment at the pyloric valve cannot be definitely ascertained. However, when the digestive tract is fully distended with food, the pyloric valve is flattened out (Fig. 15, py. v.) and the lumen of the anterior iliac chamber is continuous with that of the mid-intestine. The cells of both the anterior and posterior histoblastic rings are very similar in character.

Two urinary ducts carry the contents of the Malpighian tubes (Figs. 1 and 2, ur. d.) into the anterior chamber of the ileum. Each opens by a single pore on the lateral walls of the tube just below the pyloric valve.

The epithelial cells lining the thin walled anterior region of the ileum are very flat and their walls very indistinct, but the nuclei are prominent, oval, and contain fine chromatin granules which stain readily. The inner surface is covered with a very thin flat chitinous intima that continues in much the same manner over both the anterior and posterior regions of the ileum. The muscular wall of the anterior chamber is thin and not as well developed as that of the posterior. A few ental circular muscle fibers lie against the basement membrane and a strong band of longitudinal muscle encloses them. The ectal

circular muscles are not well developed, but the peritoneal membrane stains readily.

In the middle region of the ileum is a complicated fold, the ileal valve (Hasemann, 1910) which separates the anterior from the posterior chamber (Fig. 13, il. v.). The epithelial cells lining this valve are large and cuboidal in shape with curved walls, most of which are quite distinct. The nucleus is densely granular, the nucleolus prominent and the cytoplasm clear, reticulate in the outer half of the cells, but granular to finely vacuolate in the basal region (Fig. 16). In the depressions produced by the folded epithelial stratum, are well developed ental circular muscles, about 17 in number. Between and enclosing these muscles are longitudinal strands of muscle tissue, some of which make their insertion on the basement membrane of the larger epithelial cells. Beginning at the anterior border of the valve are at least 17-18 very large ectal circular muscles (Fig. 16, ec. c. m.) which extend slightly beyond the folds of the valve. The peritoneal membrane, continuous from the anterior region, shows distinctly, (Fig. 16, per. m.). It proceeds posteriorly over these muscles and continues over the smaller circular muscles of the posterior portion.

Posterior to the ileal fold (Fig. 13, il. v.), the epithelial cells are low, cuboidal in shape with rather indistinct cell walls. They measure between 33.8 and 37.6 microns in length and have a uniform depth of 16.9 microns. The nuclei are oval to elongate (3.8 microns by 28.2 microns) and highly chromatic. In the median and posterior region the cells are larger, some remaining cuboidal (67.6 microns by 41.4 microns; nuclear diameter 18.8 microns), other definitely irregular to polyhedral in shape (Figs. 19, 20, 21, 22). The larger cells measure 78.9 microns by 26.3 microns and possess large nuclei with coarse granular to fibrous-like chromatin. The cytoplasm of the entire epithelial layer of this region is finely granular to minutely vacuolate and contains many darker staining granules of chromatin. No normal pigmentation was observed in this region of *Homaledra*. The basement membrane is distinguishable in the fore part but weak and difficult to determine in the posterior region because of the thinness of its structure and the irregularity of the overlying cells. It can be observed in some sections over the open spaces between the cells. The chitinous intima is not especially thickened over the folds of the ileal valve or over the low cuboidal cells. Beyond the latter, however, it begins to thicken and form a heavy lining to the posterior walls of the chamber (Figs. 21 and 22, chi. i.) and then continues caudad to cover the wall of the colon.

The circular muscles are very distinct from the ileal valve back to the colon (Figs. 13 and 22, c.m.). They are at first small and oval but gradually become larger and are block-like to irregular (in cross section) in the posterior region. The smaller bundles measure 13.1 to 16.9 microns in diameter, the larger ones average about 56 microns in diameter. In longitudinal sections 52 of these circular muscles were counted. The peritoneal membrane is very distinct along the course of the smaller bundles, but barely distinguishable bordering the larger

muscles. Longitudinal muscles are weakly developed, several strands are visible in the region of the colon and just posterior to the ileal valve, (Fig. 22, 1 m.).

Several prominent clefts appear in the epithelial stratum of the ileum just before entering the colon, but no definite valvular structure is to be found in the larva. In many cases the epithelial wall is thrown into distinct folds, (Figs. 20 and 21). The lumen is considerably narrower here than in the forward region; the epithelial cells are polyhedral to oval in shape and large; the chitinous intima thickened and the circular muscles very strong. The narrow lumen of the ileum opens abruptly into the very much expanded cavity of the colon, (Fig. 22, col.).

Colon. The colon is normally short, about one-half the length of the ileum, (Figs. 1 and 2, col.). The width is very variable but is usually at least twice that of the small intestine. The chitinous intima is thinner than in the ileum and is thrown into numerous short folds in the partially filled organ, (Fig. 22, chi. i.). The epithelial layer consists of flattened, irregular to oval cells with prominent nuclei, but often indistinct cell walls, (Fig. 23). They are closely compressed by well developed circular muscles that press against the basement membrane. Longitudinal muscles are weakly developed but may be observed in delicate strands. Outer circular muscles surrounded by a peritoneal membrane complete the very substantial wall to this region, (Figs. 22 and 23). During the normal feeding of the larva this sac is greatly distended with waste food and debris.

Rectum. The posterior region of the hind-intestine is a narrow, short continuation of the digestive tract from the colon to the exterior. Commonly called the rectum or "Mastdarm" of the German workers, the tube in the larva of *Homaledra* can hardly be compared with the structure in grasshoppers, cockroaches, certain beetles and Odonata. In the various Lepidopterous larvæ studied by Bordas (1911) no differentiation of this region is reported.

The anterior region of the rectum is marked by several strong sphincter muscles (Fig. 22, sph. m.) inserted on the strong chitinous intima between the rather flat, oval epithelial cells. Their attachment is on the adjacent body wall.

The tube of the rectum is slightly bent and varies in diameter from 18.8 to 24.3 microns. The chitinous intima is thick, and is modified in the median and posterior half to form backward projecting bristles (11 to 13 microns in length), (Fig. 22, b.). At the anal opening it is continuous with the external chitinous covering of the body. The epithelial cells pass inconspicuously into the layer of epidermal cells lining the integument. The muscular layer is poorly developed and can be distinguished only over the fore and median region of the tube.

SALIVARY GLANDS OF THE MATURE LARVA.

Spinning Glands.—In Lepidopterous larvae the labial or salivary glands are modified to form silk producing organs. These are usually tubular in character and “unite to form a single duct opening into the upper lip at the end of the ligula, which is modified to form the spinneret,” (Packard, 1898: 339). Measurements from a number of Eurasian caterpillars (Helm, 1876) show the length of the glands in certain species as slightly less than the length of the body, in others slightly longer, and in some such as *Telea polyhemus* as much as seven times the body length. The typical structure and function of the spinning glands has been thoroughly reviewed by Imms (1924: 140–141) and Schroder (1912: 285–300).

The spinning or silk glands of *Homaledra* consist of two white, tubular structures about 13 mm. in length when extended. The anterior region, or salivary duct, is narrow and tubular, the posterior, or glandular portion, is thickened, tubular and bent in one or two loops, (Figs. 24 and 25). The union of the duct with the glandular area is visible externally in the dissected specimen as well as in histological sections. The ducts from the respective glands unite just before the external opening in the anterior median floor of the buccal cavity, (Fig. 26).

Functional Salivary Glands. The mandibular muscles in the head of the larva of *Homaledra* are well developed and fan-shaped. On the lower inner face of each is the mandibular gland, a tubular structure, which extends almost to the posterior border of the head, (Fig. 27). The anterior part is a thin walled duct; the posterior is secretory and consists of typical gland-like cells around a narrow lumen, (Fig. 28). Similar glands have been described from other Lepidopterous larvae (Imms, 1924:139). They are well developed in *Cossus cossus* L. (Henseval, 1897) and are short and sac-like in the larva of *Papilio alexanor* Esp. (Bordas, 1904). They have also been described from *Stauropus fagi* L. (Schroder, 1912), from *Mantis religiosa* L. (Bordas, 1907), from *Apis mellifica*, (Snodgrass, 1925) and from other insects.

Maxillary glands are also present in the larva of *Homaledra*. They are compound tubular structures that lie closely compressed in depressions on either side of the floor of the buccal cavity, (Fig. 26, max. gl.). They are situated below the mandibular glands and laterad of the spinning glands. In some specimens they appear to extend posteriorly along the lower lateral wall to near the region of the thorax. Although different in shape, the glandular structure of the cells resembles that described by McDunnough (1909) in the larva of *Chrysopa perla* L. Owing to their compressed position the exact number of tubular units could not be determined. The duct is very narrow but was observed

in many sections. The glands appear to be similar in character to those described and pictured by Henseval (1895) in the head of *Limnophilus flavicornis* Fabr.

MALPIGHIAN TUBES OF MATURE LARVA.

Similar to most Lepidopterous larvae there are six Malpighian tubes in *Homaledra*, (Figs. 1 and 2, malp. t.). Each three empty into a separate, narrow urinary duct that opens by a single pore into the lateral wall of the ileum, just below the pyloric valve. The urinary duct gives off two tubes, one proceeding posteriorly, the other anteriorly. The latter branches at once to form a long anterior tube that extends laterally along the digestive tract to about the median region of the mid-intestine, where it divides. One branch then loops around the mid-gut, but returns to proceed posteriorly with the other over the same surface. The anterior branch of the opposite side divides in a similar manner and its two ends come to lie on the opposite face of the mid-intestine. The two posterior tubes do not branch, but end free from the wall of the intestine in the anterior region of the rectum. The tubes are yellowish white in color, somewhat convoluted and have smooth walls.

Many variations have been found in the urinary tubes of Lepidopterous larvæ. Cholodkowsky (1887) found four tubes in *Galleria mellonella*; Bordas (1911) reported great variations in appearance but in all forms examined six tubes were observed, in two groups of threes, with the exception of *Carpocapsa pomonella* Fr. in which there were only four. In general the number of malpighian tubes in insects is said to be very constant within the limits of most of the orders (Imms, 1925:130-132). The number, however, varies from 2 in Coccidæ to more than 120 in certain Orthoptera.

POST-EMBRYOLOGICAL DEVELOPMENT.

After the active mature larva of *Homaledra* ceases to feed, it defecates and molts and then passes into the sixth or last instar. This usually occurs within the silken cocoon. Then the prepupal or resting period begins, during which the larva is fairly active at first, but gradually settles down, contracts, straightens its body, becomes pale in color, loses the activity of its legs and responds only slightly to touch. The duration of this instar is variable, but it is usually completed in two to

three days. In some cases it may be as short as one day, or in others it may be prolonged to four or five days. Histological changes in this species are normally slow as compared with numerous Dipterous forms that have been studied by others.

Shortly before the larva becomes immovable as a prepupa, that is, between eight to ten hours before pupation, the histoblastic or imaginal discs of the integument begin to proliferate and increase in size. These are groups of histoblastic cells that occur at intervals among the larval integumentary cells, (Fig. 29, hist. d.). They are normally small, short, and columnar and packed closely together. The cell wall is indistinguishable and the nucleus elongate, highly chromatic, staining more deeply than that of the adjacent cells. These cells begin to increase rapidly and push against the larval epidermis.

During the following three to four hours the larva becomes gradually immovable and the body is contracted. The integumentary histoblastic discs rapidly extend over the integument, (Figs. 30 and 31, i. hist. d.). The larval cells are slightly distended; the nucleus is prominent and the nucleolus large. They become vacuolated and the nucleus breaks up into small parts which on the disintegration of the cell membrane float out into the body cavity, (Figs. 30 and 31, d. l. c.). These elements have been termed "pseudonucleated globules" by Tiegs (1922) in *Nasonia* (Hymenoptera). This change can be observed along the entire course of the integument and seems to be entirely a chemical process. A few leucocytes are present in the blood and appear to digest some of the broken down cell material after it is liberated. They are not found near or in any manner attacking the normal cells.

On the disintegration of the larval cells the histoblastic cells crowd into their place and gradually assume a normal columnar appearance, (Fig. 31). A delicate outer layer of chitin is secreted and at the same time large moulting glands, arranged irregularly along the body wall, pour their contents into the area between the old body wall and the thin new layer of chitin. Although the histoblastic discs have united along the outer integument and chitin is deposited on the outer edge, the process of complete replacement is not accomplished until one or two hours after pupation. In a pupa two hours old, the chitin has thickened and in four to six hours it is very hard and pigmented. Specimens over 72 and 96 hours old offered

considerable difficulty in preparation because of their dense sclerotization. It was always necessary to remove part of the chitin in order to secure proper infiltration.

Fore-Intestine.

About the time that the integumentary histoblastic discs begin their activity, changes begin in the oesophagus. The thickened chitinous intima becomes detached from the proventriculus and oesophageal wall in the posterior region just anterior to the cardiac valve. It gradually becomes loosened and lies in twisted rolls in the lumen of the fore-intestine. Within five to six hours before pupation the pupal body shrinks (Fig. 29) within the old larval skin, and, as the chitinous lining is continuous with that of the outer wall, the former is pulled forward into the median region of the oesophagus. Meanwhile histoblastic discs are growing and replacing the larval cells that border the former buccal cavity, which is gradually obliterated as the pupal wall shrinks from the larval cuticle. When feeding ceased the proventriculus became constricted and the pyloric valve more flattened than in the normal feeding larva. Coincident with the histoblastic activity in the anterior region of the fore-gut, the histoblastic cells of the cardiac valve increase rapidly and begin to push their way in a flat compressed line anteriorly against the larval cells of the oesophagus, (Fig. 32, hist. d.). A group from the posterior margin of these cells begin to extend out into the anterior ventricular lumen. Just before pupation these latter cells form a delicate tissue-plug across the anterior end of the ventriculus, (Figs. 32 and 33, t.p.).

The fore-intestine in the larva is a straight tube, but about three to six hours before pupation, the superior frontal line of newly forming integumentary cells bends ventrally and along with the inferior frontal line bends below the former axis of the larval fore-gut. At pupation the new oesophageal opening lies diagonally below and somewhat posterior to the former buccal opening, (Fig. 34). The lumen is at that time very narrow and bordered at its exterior end by clusters of close pressing integumentary histoblastic cells, (Fig. 34, i. hist. c.). At pupation the larval muscles of the pharyngeal and oesophageal wall are quite distinct in outline. They appear clear to granular with the larval nucleus irregular and coarsely granular in the center. Striations are evident in some but rather indistinct, others have completely lost them.

In the six hour pupa the muscles in the anterior and median region of the fore-gut show further signs of disintegration. The nucleus is finely granular and scattered; the whole structure is faint in color. Numerous vacuoles are present and the muscle tissue is contracted and irregular. Owing to the small size of these muscles, the striations are difficult to see. In some of the larger head and body muscles which are undergoing similar changes at the same time, the longitudinal fibrillae appear to persist throughout the whole process, but the striations disappear completely in some.

In the six hour pupa the histoblastic cells from the integument have progressed mid-way to the anterior angle of the oesophagus and by the 11th hour they have reached the apex. The anterior muscles have completely disintegrated at this time and some of their remains can be detected in the blood along the path of the fore-gut. A few very flat to slightly triangular-like dark staining myoblast cells can be seen in the near region of the cardiac valve where the disintegration of the larval muscles appear to be a little more rapid. By the 11th hour the histoblastic cells from the cardiac valve, which began to increase at the same time as the integumentary histoblastic cells, have slowly grown anteriorly to a point about mid-way from the cardiac valve to the apex of the bent oesophagus. The larval cells become enlarged and the contents appear granular with numerous vacuoles in the cytoplasm and in the nucleoplasm. The nucleus breaks up into bits; the wall disintegrates and the contents pass off into the body cavity. The process is almost identical with the degeneration and disintegration of the larval integumentary cells. The new cells lie flat with elongated nuclei parallel to the lumen of the oesophagus. Even before the larval cells are completely disintegrated the histoblastic cells have formed a thin sheet, lining the lumen.

The two sheets of growing cells, the anterior originating from the integumentary histoblastic discs, the posterior from the histoblastic cells of the region of the cardiac valve, finally meet and fuse in the 32 hour pupa. The larval epithelial cells are still disintegrating and only the larval muscles in the region of the apex of the oesophagus persist in their original outline. A thin line of myoblasts line the posterior region of the oesophagus and a few scattered ones appear near the anterior portion. At the 30th hour a thin line of chitin is being secreted along the anterior wall of the lumen.

By the 40th hour after pupation the larval muscles surrounding the apex of the new oesophagus have completely broken down and the thin myoblasts occupy their place. In the 48th hour pupa the myoblasts have increased in size and are connected by thin strands. In the 72nd hour pupa the oesophageal epithelial cells have assumed their final character in all but the posterior region. They form a narrow syncytium-like layer with flattened elongated nuclei scattered irregularly along the wall. A thin layer of chitin forms a continuous inner lining to the entire passage. The muscular wall though thin and weakly developed is complete at this period, (Fig. 35).

Leucocytes are rare in the median and anterior region of the oesophagus but more abundant near the cardiac valve. They appear near the disintegrating muscles and often close to the histolyzing epithelial cells, but do not attack them until the latter have broken out into the blood space. The various processes that result in the dissolution of the larval cells of the pharynx and oesophagus, as well as the destruction of the associated muscles are apparently due to chemical reactions that occur within the tissues themselves or in the blood of the insect during this period. There is no evidence to show any indication of phagocytosis.

Oesophageal Diverticulum. In the 60 hour pupa, a small pouch or diverticulum begins to appear in the wall of the oesophagus just anterior to the closely packed layer of histoblastic cells forming at the cardiac valve, (Fig. 36, oes. div.). The myoblasts follow the outgrowth of histoblastic cells that compose this structure (Fig. 37, hist. c.) and lie in a loose line about the periphery, (Fig. 37, my.). The position of the diverticulum at first is at right angles to the axis of the oesophagus, but by the 96th hour its epithelial cells have formed a thin walled pouch that lies along the side of the anterior end of the ventriculus, (Fig. 38, oes. div.). The length at this age is .6 mm. (600 microns), the greatest width in the median region, .075 mm. (75 microns), and the thickness of the wall uniformly 7.5 microns. The myoblasts have united and form a thin barely distinguishable muscular sheath about the diverticulum.

In the pupa of 120 hours the oesophageal diverticulum has increased in length to 1.1 mm. and the walls are partially collapsed, (Fig. 39, oes. div.). The histological structure shows a thin multi-nucleated syncytium with a delicate line of muscle tissue about it, (Fig. 40, oes. div.). The lumen contains a finely granular substance, which may either disappear later or remain in the pouch.

The diverticulum reaches its greatest length (1.4 mm.) in the 168th hour pupa and at this stage its growth is practically complete, (Fig. 41, oes. div.). The cavity may be collapsed or distended at this time. In the majority of cases where it is distended the lumen is mostly empty. No further change is noticeable until the 384th hour when the epithelial cells lining the cavity begin to round out and a definite membrane of chitinous material forms an inner tubular lining to the pouch, (Fig. 42, chi. l.). This lies free from the cells of the wall of the diverticulum, but is attached to the histoblastic cells at the point of the opening into the oesophagus.

By the time the cardiac valve opens, the histoblastic cells in that region have multiplied and formed a thickened multinuclear deep staining structure that forms a sort of collar between the cavity of the ventriculus and the oesophagus. The oesophageal diverticulum enters the oesophagus at the anterior border of this thickened wall, (Fig. 42). In the imago this pouch is non-functional. Dissections show many modifications in its shape and size, (Figs. 43, 44, 45, 46). Usually it is greatly contracted but when expanded it is mostly full of air, (Fig. 45, oes. div.).

Mid-Intestine.

All the undigested and coarse granular food material present in the last feeding stage has been removed from the ventriculus by the time the histoblastic cells in the region of the cardiac valve begin to proliferate. By the time of pupation a tissue plug is completed in this region and forms a complete membrane over the lumen, closing the ventriculus anteriorly. It has thin points of attachment with the remaining cells of the histoblastic ring. The median part of the plug is enlarged and consists of closely pressed irregular to polyhedral shaped cells with small dark staining nuclei, (Fig. 33, t. p.).

The histoblastic cells in the region of the pyloric valve also begin to increase at the same time as do those in the region of the cardiac valve. Their action is similar to those in the forward region and a tissue plug is also formed in this region, but is not complete until six hours after the pupa has formed, (Fig. 47, t. p.). During this interval, however, the products of the ventriculus do not enter the posterior intestine. This is probably due to the inactivity of the muscular wall, the viscid nature of the cellular secretions and the consolidations of the contents to form a bulky "yellow body."

As the anterior and posterior histoblastic areas begin to increase, there are very definite changes in the structure and contents of the ventriculus. With the absence of food in the lumen the epithelial cells begin at once to secrete a finely granular substance. This is viscid in nature and fills the entire cavity. The distal portion of the cells become swollen and contain many chromatin granules and vacuoles. The median and basal regions of the cells are coarsely vacuolate to reticulate and apparently empty except for the nucleus, which remains in the contracted, narrow basal region. At first, only a clear homogeneous secretion is thrown off, but this is followed by larger globules which contain most of the chromatic material of the cells. The first secretion has been termed the "yellow body" by Mansour (1927) in *Calandra oryzae* Linn. Pérez (1910) applies a similar use of the term in *Calliphora erythrocephala* Meigen but pictures a somewhat later stage. Although this may be considered the beginning of the formation of the yellow body, it is not completed in *Homaledra* until pupation.

In many cases all but the basal part of the cell is ejected. The contents of the cavity offers a very complex appearance. The center is clear to coarsely granular and the circumference is densely packed with the globules of cell contents. At this time the entire ventricular wall begins to contract and numerous folds occur along its entire structure. This action is accompanied by a gradual loosening or dissolution of the base of the cells from the basement membrane, (Fig. 48). The latter containing the larval nuclei move into the lumen and press against the already compact contents. This process occurs at the same time along the entire ventricular wall and is probably the result of chemical action. It is doubtful if any muscular activity is available to accomplish this as the slight folding of the wall could not produce such an effect.

At the beginning of this process the replacement cells (Fig. 48, r. c.) at the base of the epithelial cells appear as in the larvæ. Succeeding intervals show them slightly enlarged and much more numerous. The factors that bring about the degeneration of the epithelial cells do not affect the replacement cells in any visible manner. Immediately after the larval cells are sloughed off, the replacement cells multiply and cover the basement membrane lining the ventricular cavity. They expand and become typical low cuboidal to low columnar cells not over 23 microns in height, (Fig. 33, v. epith. c.). Pupation finds the epithelial walls lined with these cells; the central body-contracted into a somewhat lobulated structure with a lighter, granular median region surrounded by semi-fibrous strands, densely lined with degenerating

larval nuclei, (Fig. 49). Lying next this compact mass or "yellow body" (Fig. 49, y. b.) is a finely granular and reticulate substance that separates it from the newly formed epithelial cells, (Fig. 49, s.e.c.). Pérez describes the completed "yellow body" in *Calliphora* as a sort of cystic body, divided into chambers which are surrounded by very small flattened nuclei, quite different from the larger oval nuclei that line the inner divisions. No distinguishable difference can be observed in the scattered nuclei in the "yellow body" of *Homaledra*.

The "yellow body" was originally observed by Dufour (1846) and later interpreted as the remains of the proventriculus by Weismann (1864). It was first observed to be an agglomerated mass of exuviated epithelial cells by Ganin (1876). Lowne (1890-1895), Van Rees (1888), Kowalevsky (1887), and Pérez (1910) have described the structure. Pérez (1910) believed that certain digestive ferments are secreted from this mass of degenerating cell tissue. A similar function is attributed to the "accumulation of granular debris" in the mid-intestine of *Nasonia* by Tiegs (1922). The latter worker especially emphasizes the importance of this mass, which is gradually reduced in size during the pupal growth, as a probable source of nutrition to the forming imago. Observations indicate similar function in *Homaledra*.

Six hours after pupation the "yellow body" has contracted to about one third the diameter of the ventricular lumen and is beginning to show some signs of chemical disintegration. The nuclei are reduced and scattered irregularly through a densely granular but homogenous mass. By 11 to 12 hours after pupation, the central mass may be found broken into two or three parts. It is then greatly reduced and surrounded by a finely granular, dense, spongioplasm-like substance that fills the lumen.

After the liberation of the larval epithelial cells, the ventricular wall resumes its smooth outline. In the six hour pupa the ventriculus is an elongated oval body with narrow conical neck and funnel-like base. The epithelial cells in the basal region have begun to proliferate in the fifth to sixth hour and by the eleventh hour they have formed an irregular mass of cells (Fig. 47, m. v. e. c.) that close over the tissue plug, produced in the region of the pyloric valve. The cell walls in this mass are compressed, but distinct. The cytoplasm is clear to vacuolate and the nuclei are irregularly placed. This mass of epithelial cells may completely fill the funnel-like lumen at the end of twenty-four hours. Further increase is prevented by changes within the epithelial cells themselves.

In the twenty-four hour pupa the epithelial cells of the ventriculus have begun to increase slightly in size. The free ends enlarge and the cells become elongate and pear shaped, (Fig. 50.). By thirty-six hours the cells have increased in height from 16 to 18 microns to 28 microns in the anterior and median region and from 28 to 90 microns in the posterior portion. Small vacuoles form in the twenty-four hour stage and the cells soon appear as if full of small droplets which adhere together. This forms a dark staining mass that forces its way out at the surface. New masses appear to follow and in the elongated cells

of the thirty-six hour stage several of these masses occur in the cell at the same time, (Fig. 51). With the enlargement of the distal end of the cell, the basal part becomes narrow and numerous replacement cells may be seen between the bases of the epithelial cells. Disgorged cells seem to retain the nuclei in most cases, although some of the cells seem to be loosened at the base. Relatively few nuclei can be found among the cellular secretions. Many of the epithelial cells are replaced by the replacement cells at their base. This process can be observed in all stages of development. The new mass of finely granular, vacuolated substance along with many of the cells completely fills the lumen and surrounds the "yellow body," now reduced in size and stained considerably darker. This period of excessive cellular secretion precedes the presence of vast numbers of leucocytes through the body cavity. The duration of this condition varies somewhat. In the average pupa of forty hours the process is almost complete but in some cases it may continue as late as the 72nd hour. Usually, however, the secretory process is completed by the 48th hour pupa and the epithelial layer has returned to its former, low, characteristic cuboidal cells.

During the interval from the 48th to the 120th hour there are no further changes in the cell structure, and their growth is slight, still remaining cuboidal in shape. Between the 96th and 100th hour there is a slight renewal of the former secretory process, but it does not appear to cause any excessive destruction or renewal of cell tissue. By the 152nd hour (6½ days) the cells are cuboidal again, tending to low columnar at forward and posterior ends. The nucleus is small, circular, and in the basal or median region of the cell. The cytoplasm is clear, closely vacuolated and contains very little chromatic staining material. The contents of the ventriculus, has been undergoing a slow degeneration. By the 96th hour the fibrous nucleated nature of the original "yellow body" has disappeared and a coarse granulated irregular mass fills the lumen. Absorption of some of the fluid contents follows, accompanied by a further granulation of the larger particles of debris. The body of the posterior tissue plug has been changing. After the 144th hour an internal degeneration has set in and its definite cell structure disappears. The enclosing tissue walls, however, remain intact, (Fig. 52, t. p.). In the pupa of 168 hours the mass is still coarsely granular, yellowish brown in color and forms a coherent body lying in the posterior region of the ventriculus. In some cases it retains its integrity until after the opening of the pyloric valve. Usually this solid mass breaks up into scattered granular to flocculent particles about the 246th hour. Meanwhile, at the 264th hour the pyloric valve opens and the entire contents of the ventriculus passes into the hind-intestine, (Fig. 53).

In sections from pupa 114 hours old and older there may be seen very small single replacement cells between the bases of the epithelial cells. They increase slightly in size with the age of the pupa and occasionally small clusters of such cells can be found. They persist in this condition through the pupal development and pass unchanged

into the imago. Although not as abundant as in the larva and early stages of the pupa these replacement cells may be found somewhat reduced and at irregular intervals along the basement membrane in the adult. They do not appear to proliferate further in the imago.

The epithelial cells begin to change from cuboidal to columnar in the 288 hour pupa. The growth proceeds slowly over the entire surface. No difference in regions can be noticed until the 348 hour pupa. The lumen at this stage has lost its distinctly circular appearance, and it has become irregular in shape. The epithelial cells in the anterior region are crowded and columnar, (Fig. 54). The cytoplasm is granular, the nucleus small and situated in the basal portion of the cell. The epithelial cells in the median region are short columnar, not closely compressed except at the angles of the ventriculus, (Fig. 55). The latter has become triradiate in shape. The lining of the posterior wall of the ventriculus is but slightly changed. It is lined with low and densely stained cuboidal cells. The cells of the anterior and median regions continue to elongate and the lumen is gradually compressed to a narrow slit-like opening, (Fig. 56, lu.).

The anterior tissue-plug is forced apart and the cardiac valve opens at the 384th hour, (Fig. 42). At this time the striated hem appears as a narrow border (Fig. 42, s. b.) along the free edges of the epithelial cells. It is between 1 to 2.5 microns in thickness. The ventriculus is now an elongated empty sac with somewhat compressed walls and open at both ends, (Fig. 43, 44, 45, 46). Within the next 24 to 48 hours the imago emerges.

In some specimens, before emergence, a substance is secreted into the ventricular cavity that appears finely granular in character. This occurs after the 384th hour and tends to distend the wall. This is more evident in the male specimens which are usually smaller than the females. It is also observed in some of the females, but generally the ventriculus is distended with air, (Figs. 44 and 45). The volume seems to increase with the age of the adult. The average seldom live over a minimum of 10 to 12 days. As the fore-intestine is empty and the insect does not feed, no additional substances enter the ventriculus.

Muscular wall. The muscular wall of the mid-intestine is so weakly developed that changes within its structure are extremely difficult to follow. No visible modifications were observed until the 96 hour pupa, which was about the end of the period of secretion by the epithelial cells. The muscles then become clear and their outline is indistinct; they are surrounded by large numbers of leucocytes which predominate in the blood at this time. By the 120th hour the larval muscles have been obliterated and a fine line of myoblasts have arranged themselves near to the basement membrane which has remained intact throughout the entire development. The myoblasts grow slowly and by the 160th and 168th hours they are fairly plain. It is not, however, until the 192nd hour that the longitudinal muscles can be definitely seen and the new circular muscles are not distinct until the 216 hour pupa. No further changes were observed to occur.

Hind-Intestine.

After the last defecation of the larva, 12 to 14 hours before pupation the lumen of the entire larval hind-intestine collapses. It then appears as a more or less straight tube extending from the pyloric valve to the posterior tip of the larval body.

The initial changes in the hind-intestine are coincident with those of the fore-intestine. Beginning between 8 and 10 hours before pupation the integumentary histoblastic discs along the posterior body wall begin to increase and displace the larval epithelial cells. Within 4 to 5 hours the forming pupal integument shrinks from the larval wall and the chitinous lining of the hind-intestine is loosened from its course. The posterior opening of the intestinal tract is very wide at this time, (Fig. 57).

With the increased growth of the integumentary histoblastic cells, the muscles of the hind-intestinal wall as well as the large sphincter muscles attached to it begin to show signs of degeneration. The process is at first most evident in the circular muscles of the larval small intestine. Their structure, 5 hours before pupation, has become finely granular, many vacuoles are present and the striations are scarcely visible. The larval nucleus remains prominent but coarsely granular, (Fig. 58, c. m.). At this time the sphincter muscles and certain body muscles begin to lose their striations and vacuolation begins near the outer edge. The striations then become irregular and finally disappear but the fibrillæ remain distinct in the larger muscles. The nuclei pass to the outer margin and lie just within the scarcolemma, which remains intact.

On pupation the larval cuticle is exuded and the chitinous lining of the hind-gut is thrown off. The result is a complete collapse of the entire lumen and the contraction of the integumentary wall in the region of the posterior opening. The histoblastic cells from the integument in this region begin to increase and form a dense cluster of cells, in some cases several layers deep. These new cells lie in direct contact with old larval epithelial cells of the posterior wall and replace them in the same manner as in the fore-intestine. At pupation the larval epithelial cells lining the hind-gut are swollen. They are coarsely granular, contain numerous vacuoles and show general signs of degeneration. The muscles of the anterior and posterior walls have begun to break up and the scarcolemma has disappeared from all but a few of the muscle bundles in the median region. The sphincter muscles have become granular in appearance, the striations persisting in only a small area and there very indistinct and irregular. The substance of the muscle is greatly shrunken and the larval nuclei line the periphery.

Although the "tissue plug" closing the opening between the mid-intestine and hind-intestine is not complete until 6 hours after pupation, the histoblastic cells in the region of the pyloric valve have increased greatly in number, (Fig. 47, hist. c.). They form a dense cluster of cells at the anterior end of the intestine. In the pupa 2½ hours old this mass of newly formed cells begins to push its way posteriorly in the

channel of the larval hind-intestine. The latter is now in a state of active disintegration in this region. The breaking down of the larval muscles and epithelial cells proceeds from the anterior and posterior and simultaneously as the new cells advance from the germinal discs (one group from the region of the pyloric valve, the other from the integumentary cells). This process continues and in the 18 hour pupa numerous leucocytes congregate about the dead muscle tissue (Fig. 59). The advancing columns of epithelial cells meet, in some cases at 24 hours after pupation, in others not until 30 hours. In either case the new cells form a narrow thin tube with nuclei parallel to the axis of the lumen. In the 24 hour pupa numerous flattened spindle-like to triangular cells appear in the blood in the posterior region near the hind-intestine. These cells, or myoblasts, arrange themselves along the wall of the hind-gut. They are very evident in the 30 hour pupa and lie parallel along the wall amidst the debris of dead larval muscles and epithelial cells. The destruction of this dead material is partly accomplished by leucocytes that surround it during the period from 18 to 48 hours. They do not attack any of the normal tissue and only seem to engulf particles that have broken out into the blood space.

At the end of 48 hours most of the larval debris has disappeared and the anterior cells lining the posterior intestine have expanded slightly. Their nuclei are still flat and parallel with the axis of the lumen. The myoblasts have united in the anterior region to form a thin multinucleated muscle layer that lies close to the outer edge of the new epithelial cells. In the median region of the hind-gut the lumen has commenced to expand and the nuclei of the epithelial cells lie at an angle with the axis of the lumen. This is the beginning of the large intestine of the adult, (Fig. 60). Its future structure and function show it to be really a combination of the colon and rectum. In the 72 hour pupa the lumen of this area has expanded and the region anterior to it, or small intestine, has become a narrow tube lined with a thin multinucleated syncytium-like epithelial layer with compressed oval nuclei and definite muscular wall.

At the point where the small intestine opens into the expanded and somewhat thinner walled large intestine, there is gradually developed a valve-like structure. This is an ileo-colic or mid-intestinal valve and begins to form in the 120 hour pupa, (Fig. 61, il. col. v.). It is first indicated by an elongation of the nuclei and an outgrowth of the cell wall into the lumen. The cells appear in many respects similar to the histoblastic cells. They proceed to grow and extend as a multinucleated irregular protuberance into the anterior growth of the large intestine, (Fig. 62, il. col. v.). The growth is completed at about the 216 hour, (Fig. 63, il. col. v.). Although occupying the position of a valve the tissues do not appear to close the lumen at any time.

With the beginning of a distinct differentiation between the fore and hind parts of the posterior intestine in the 120 hour pupa, there follows a uniform expanding of the wall of the posterior region from the ileo-colic valve to the anal aperture. The epithelial stratum in the expanded

region, which before showed a rather irregular margin is now pulled out into a very narrow line with smooth border, (Fig. 64).

At the same time as the ileo-colic valve is forming certain epithelial cells along the wall of the posterior portion of the hind-intestine begin to show similar modifications. The nuclei elongate, increase in number and the cell walls protrude into the lumen. In the 120 hour pupa several of these areas may be observed, but at that time they appear only as thickenings of the epithelial stratum, (Fig. 65). In the 144 hour pupa a basal multinucleated area is seen and an anterior, typical glandular structure, (Figs. 66 and 67), with several nuclei, oval to irregular in shape and others elongate and spindle-like. The cell walls are partly visible; the cytoplasm is clear and lightly granular. These outgrowths are true rectal glands. They increase slowly in size and reach their maxim dimensions in the 168 hour pupa, (Fig. 68). In many cases a distinct lumen can be seen between the basal and anterior structure and a thin layer of chitin over the free surface. In *Homaledra* there are six of these rectal glands arranged irregularly on the wall in the posterior region of the hind-intestine. No further change was observed in the structure. In the imago of 3 to 10 days old, they appear slightly reduced in size but essentially the same in structure.

Although the large intestine begins to expand in the 120 hour pupa, the pyloric valve does not open until the 264th hour. Just previous to the 120th hour, the posterior wall of the hind-intestine is completed and is very similar to that of the anterior region. The epithelial stratum is slightly thicker, the nuclei are larger and more granular and the muscular layer distinct but weakly developed. In the 258 hour pupa a delicate chitinous membrane is being formed along the entire course of the large intestine from the ileo-colic valve to the anal opening. At the same time, the growth of a heavy muscular wall about the posterior genital tubes causes a bend in the course of the posterior third of the large intestine and also a compression of the lumen. The compressed portion of the intestine becomes a narrow tubular structure and may be considered as the rectum or anal tube, (Fig. 69, a. t.). As it is merely a narrow passage way to the exterior and does not serve as a storage place for any waste material, it does not represent the characteristic rectum of insects. The function of storage is associated in *Homaledra* with the large intestine. The presence of the glands in the former structure further add to the possibility that the posterior tube is nothing more than an extension of the large intestine and should be considered only as a "rectal tube."

On the opening of the pyloric valve the contents of the ventriculus pour slowly into the large intestine and gradually distend it, (Fig. 69). This material is retained in the thin chitinous membrane that lines the cavity. The wall of the posterior region, or rectal tube, collapses and the chitinous lining of its wall is bunched up into one or more compressed lumps or plate-like structures (Fig. 69, chi. i.) that completely block the median to posterior end. In most specimens there are several folds in the wall just posterior to the opening of the large intestine. Further granulation of the intestinal debris takes place in the large

intestine. It remains in this chamber until the emergence of the imago (i.e. from the 264th hour to a time varying between the 402nd and 432nd hour of pupation). The chitinous plug in the anal aperture often adheres to the chitinous wall of the pupa. On the emergence of the adult this is pulled out and exuded with the pupal case.

Shortly after the imago emerges part of the finely granular substance in the large intestine is voided as the meconium. In many adults the greater part of this substance seems to be retained. This proved to be the case with laboratory raised specimens as well as with those collected from the field. Even in specimens 10 days old the large intestine was often filled, although the fore and mid-intestine was filled with air. In all probability it serves as a source of nutriment to the adult as the fat body in the latter is greatly reduced. Furthermore, dissections show a gradual reduction or absorption of this substance during the life of the imago in cases where the contents had not been voided at eclosion. Verson (1905) has shown that these degeneration products are voided through the anus in the silkworm. Tiegs (1922), in *Nasonia* found them to be stored in the posterior intestine. He further attributes considerable nutritive value to the intestinal debris and states that "if the observations of Verson are correct, the process offers a curious type of inefficiency—the waste of certain useful storage materials—which does not occur in *Nasonia*."

Salivary Glands.

Spinning Glands: The spinning glands are morphologically labial glands but homologous with the true salivary glands of other insects, (Imms, 1925:407). The anatomy and histology of these glands have been studied in many Lepidopterous larvæ: Helm, (1876), Englemann (1880), Blanc (1889, 1891), Gilson (1890), Verson and Bisson (1891), and more recently by Tanaka (1924).

The spinning or silk glands of *Homaledra* are very similar to those of other larvæ of the same order, (Figs. 25, 26, and 70). There is a thin outer membrane or tunica propria and an inner chitinous lining, the tunica intima, (Fig. 71). In the secreting glands the tunica intima has distinct transverse striations. The epithelial cells of the glandular area are very large, polyhedral in shape and possess curious irregular shaped nuclei, (Figs. 70 and 72). As the glands produce their secretions the epithelial cells flatten out and the lumen becomes filled with a mass of clear viscid appearing globules, (Fig. 71). After the liberation of the silk, the epithelial cells again expand and the cytoplasm contains many large empty vacuoles, (Fig. 70).

In the early prepupal stage of *Homaledra* the contents of the spinning glands are used in preparing the silken tunnel, or cocoon, in which pupation takes place. Therefore, just before pupation the glandular contents are reduced, (Fig. 73). The epithelial cells are somewhat contracted and the cytoplasm is finely granular in character. At pupation a further reduction has occurred and the glandular region is slightly indented. Although still irregular the nuclei have contracted

and are more or less globular in shape. Further contraction occurs along this region, and in the 12 to 18 hour pupa the anterior region is deeply lobed and densely granular, (Figs. 74 and 75). At the same time the nuclei in the larger glandular area have begun to disintegrate. Many small vacuoles appear in the cytoplasm and the cell walls break down, (Fig. 76). In the 24 hour pupa large clear areas have formed below and at intervals along the periphery of the tunica propria, (Fig. 77). The identity of the cells has been lost and the entire contents converted into a mass of disintegrating nuclei, coarse granules and vacuoles. These final stages in histolysis do not occur in the salivary ducts. The walls contract after pupation, the nuclei become globular to irregular and large vacuoles appear throughout the cytoplasm, (Fig. 78). The lumen, although contracted is not obliterated as it is in the glandular area.

Between the 24 to 27 hour pupa leucocytes begin to congregate along the walls of the glandular region, (Fig. 77, leu.). They lie along the wall at first but as the latter is destroyed, they penetrate into the disintegrating tissue. Phagocytosis begins in the posterior and median region and proceeds anteriorly to the base of the salivary ducts, (Fig. 79). A few scattering remains of the nuclei may be found in the 48 hour pupa but by the 72 hour pupa the visible signs of the organ have disappeared.

The salivary duct continues to shrink in diameter and appears to undergo a complete reduction in the size of its parts, (Fig. 78). No leucocytes were observed attacking it at any time. Following the granular disintegration and later phagocytosis of the glandular region the ducts remain as very slender glandular-like tubes extending into the median region of the thorax. The lumen is very narrow, the epithelial cells very flat and the nuclei very irregular, like miniature representations of the former salivary nuclei, (Fig. 80). By the 120th hour these tubes have reached their final stage of metamorphosis and persist unchanged through the remaining pupal period and pass into the adult. These structures in the adult moth appear to be non-functional, as they show no cellular changes in adults of various ages. This might be expected as the adult does not feed. In the imago these structures may be termed "thoracic glands" as they resemble the "Thoracaldrusen" described by (McDunnough, 1909:351) in the adult of *Chrysopa perla* L.

The destruction of the spinning glands in *Homaledra* resembles that described by Tiegs, (1922:449, 450) in *Nasonia* (Hymenoptera) and by Pérez (1910:139-150) in *Calliphora* (Diptera). The size of the organ and relatively large component cells greatly facilitate the observations. That the process is first one of chemical action resulting in death and granular degeneration of the parts, followed by phagocytosis, there can be little doubt. Tiegs (1922:450) states in regard to *Nasonia* "salivary glands, in their degeneration, offer as clear an example of phagocytosis as it is possible to wish for. But their death, degeneration, and even partial disintegration previous to phagocytosis are equally clear."

Functional Salivary Glands: The maxillary and mandibular glands of the larvæ undergo a similar degeneration to the spinning glands. This appears to be entirely of chemical origin as they are not attacked by the leucocytes. Their complete disappearance is accomplished by the 10th hour of pupal life.

Malpighian Tubes.

The Malpighian tubes in *Homaledra* persist from the larval to adult stage, but exhibit some modifications in structure, (Figs. 1, 2, 43, 44, 45, 46). The larval urinary ducts, however, are completely destroyed and remade into somewhat larger structures in the imago, (Figs. 43, 44, 45, 46: ur. d.).

In the actively feeding mature larva the Malpighian tubes (Figs. 1 and 2, palp. t.) appear on the surface to be composed of uniform rectangular cells which in cross section show as long low cuboidal epithelial cells, (Figs. 81, 82, 83). The nucleus is usually irregular in shape and may consist of a number of parts, (Fig. 81, nuc.). In cross section these seem to lie in the median region of the cells, (Fig. 83). In the distended tubes an inner and outer zone can be detected and in such cases the contents of the lumen appear finely vacuolated with minute granules throughout its structure. Numerous small crystals may also be found, (Fig. 84). In partially filled tubes the basal regions of the cells appear denser and more granular than the region near the lumen which is finely vacuolated, (Figs. 82 and 83). The enveloping membrane of tunica propria is distinct and shows plainly in all the preparations.

Three hours before pupation the walls of the tubes have developed an undulating outline and many of the cells have expanded so as to produce a somewhat lobulated effect. The individual cell walls have become very indistinct and are almost obliterated in some cases. The nucleus has contracted into an irregular fibrous-like mass and the cytoplasm is granular throughout with numerous clear vacuoles near the peripheral wall, (Fig. 85). At pupation each nucleus appears as a densely chromatic irregular to oval mass, (Fig. 86), the vacuoles along the outer wall have increased and many have coalesced. The finely granular material has been pushed to the lining of the lumen. The latter is still discernable. In the six hour pupa there is no apparent change but in the tenth and eleventh hour pupa the large vacuoles have disappeared from the cellular layer, the nuclei have lost their fibrous character and appear as dark granular masses. The lumen has again expanded and shows a narrow epithelial margin of finely granular to very minute vacuoles and nuclei scattered at intervals along its length. The entire diameter of the tubes is greatly reduced. No further changes occur in the structure of the tubes except that the nuclei in the imago become more prominent and definitely oval in outline. The cytoplasm also becomes more granular and staining shows the presence of more chromatic material.

The urinary duct of the larva is a tubular structure lined with an irregular multinucleated layer of epithelial cells, (Fig. 87, ur. d.). At

the entrance to the tubes the epithelial stratum forms a small infolded lip or valve in which the nuclei are more numerous, (Fig. 86, v.).

The same degeneration processes that destroy the larval hind-gut seem to bring about the elimination of the urinary duct. The larval epithelial cells lining the wall break down in the same manner as that of the intestine and new histoblastic cells push in to occupy their place, (Fig. 47). Between the 2nd and 3rd hour after pupation, the histoblastic cells from the pyloric valve begin to push their way around the orifice of the larval urinary duct, (Fig. 88, hist. c.). They grow and proliferate in identically the same manner as those in the intestine. The epithelial layer is completed at the same time as that of the small intestine. The muscular wall is formed in the same manner and also coincident with the anterior intestinal wall. The orifice leading into the intestine remains as a small circular aperture between triangularly compressed walls, (Fig. 89).

The Malpighian tubes of the imago loop about the mid-intestine, (Figs. 43, 44, 45, 46, malp. t.). Their walls are smooth and in dissected specimens they appear as dirty white tubes. The process of histolysis and histogenesis has resulted in the formation of delicate thread-like structures somewhat similar to the larval organs but greatly reduced in size in both diameter and length. The malpighian tubes in the adult end over the extreme anterior region of the small intestine.

COMPARISON OF HOMALEDRAS WITH OTHER FORMS

Many careful investigations have been conducted on post-embryological developments in insects since the memoir on the blow-fly (*Calliphora*) by Weismann in 1864. These studies have resulted in some divergent ideas relative to the metamorphic changes occurring within the insect body. The present study of *Homaledra* corroborates the views of many of the more recent workers in other groups. Only a brief comparison of some of the previous findings can be included here. The work is extensive and bibliographies on the subject are voluminous. Each species offers certain modifications, although certain groups are more or less consistent; methods of technique and quality of material have been very variable and certain misrepresentations have been possible.

Weismann (1864) observed that the larval epithelial cells of *Calliphora* passed into the lumen of the digestive tract and were replaced by areas of cells which he called "imaginal discs." The disintegration was accomplished by certain rounded cells, named by him "Kornchenkugeln." Ganin (1876) found imaginal "nests" in certain Dipterous larvæ at the end of the mid-gut and stated that the imaginal mid-gut epithelium

was formed from these. In 1883, Metschnikoff working on Muscid pupa explained the destruction of larval tissues by phagocytes, but these were later shown by the researches of Kowalevsky (1885) and Van Rees (1888) to be engorged leucocytes. Kowalevsky also showed the presence of an imaginal ring of generative cells at the junction of the fore-gut and mid-gut in certain *Chironomus*, *Corethra*, and *Culex* species. Other workers on Diptera to confirm the presence of imaginal rings in the fore- and hind-gut and replacement cells among the epithelial cells of the mid-gut were Hurst (1890), Vaney (1902), and Thompson (1905). Although Snodgrass (1924) did not study the post-embryological changes in *Rhagoletis pomonella* Walsh (Diptera), he makes the general statement that the fore and hind-gut epithelium is replaced from imaginal buds in the intestinal wall. Thompson (1905), was one of the first to doubt the presence of phagocytosis in the alimentary canal of certain *Culex* and *Anopheles* larvæ, upon which his investigations were based.

The earlier workers interpreted phagocytosis generally as phagocytosis of living tissues. Berlese (1901) claimed that some internal disintegration must precede the activity of any leucocytes or amoebocytes in the blood.

Later Metalnikoff (1908) showed the destruction of the muscles of the alimentary canal in the wax moth *Galleria mellonella* by large numbers of leucocytes.

Pérez (1910) attached considerable importance to "les spheres des granules" in the destruction of larval tissue, but Poyarkoff (1910) working on a Coleopterous form *Galeruca* differentiated between phagocytic histolysis and cellular rejuvenation.

In the Hymenoptera, Pérez (1910) has shown in *Polistes gallica* that the epithelial cells of the mid-gut are replaced by certain cells at their base. Oertel (1928) working with the same order, showed the presence of imaginal rings and replacement cells in the honeybee. Matheson (1912) observed that the larval cells in *Corydalus* (Neuroptera) became active and formed the lining of the imaginal fore-gut. In the order Thysanoptera, Muller (1927) showed the presence of a fore and hind-gut respectively, with proliferation cells to form the fore and hind-gut respectively, with replacement cells lining the walls of the mid-intestine.

Many workers have disclaimed the exclusive importance of the leucocytes in destroying the living or dead tissue. The theory of degeneration, which involves the preliminary chemical dissolution and death of the tissue before destruction by these cells has been believed by many workers for a long time. Recent studies by Tiegs (1922), on the Chalcid *Nasonia*, Müller (1927) on *Parthenothrips dracaene* and Oertel (1928) on *Apis mellifica* fully confirm this theory. The present study of *Homaledra* shows a definite chemical degeneration followed in some organs by a rejuvenation, in others by a dissolution and partial absorption by leucocytes.

SUMMARY

1. The present investigation was undertaken with the view of studying certain morphological changes that occur in Lepidoptera, especially in reference to certain points of metamorphosis that have been demonstrated in some of the other orders.

2. A brief historical survey of the principal workers on the alimentary canal in Lepidoptera is included. Only a few post-embryological studies have been made on members of this order. Mention is made of some of the students of other groups.

3. The species selected for study was *Homaledra sabalella* Chambers, the palm-leaf skeletonizer of Florida and certain of the West Indies. The life history has recently been studied by Creighton (1929). The pupal period extends from 17 to 20 days. Notes on the habits and life of the larvæ are included.

4. All specimens used were collected and prepared at Gainesville, Florida, where the species is very common. Exact methods of securing pupa of the correct age are described as well as the technique of preparing slides.

5. The digestive system of the mature larva is a somewhat straight tube extending throughout the length of the body. The buccal cavity is rather definite and leads into a short and narrowed pharynx, easily distinguished by its characteristic overlapping lateral folds, bristles, and dorsal chitinous plates.

The oesophagus begins at the supra-oesophageal ganglion and passes into an expanded proventriculus. The latter joins the ventriculus at a distinct cardiac or oesophageal valve in which is found a ring of histoblastic cells.

The ventriculus is elongate, tubular, with characteristic epithelial cells with small replacement cells at the bases. A pyloric valve, also with a ring of histoblastic cells, separates the ventriculus from the hind-intestine.

The ileum is divided into an anterior and posterior chamber, separated by a very prominent ileal valve. The urinary ducts open into the lateral walls of the anterior chamber.

The colon, though normally short, is capable of considerable expansion. The musculature of the wall of both ileum and colon is quite complete and complicated. The colon empties into a short tube, or rectum, which passes to the anal aperture. The median and posterior wall of the rectum is lined with bristle-like projections from the chitinous intima.

6. The salivary glands in *Homaledra* are modified to form two elongate, often folded, spinning glands. These may extend almost the entire length of the body.

The functional salivary glands consist of the mandibular and maxillary glands.

The mandibular glands are small elongated structures lying on the inner face of each mandibular muscle. The maxillary glands are tubular structures lying laterad of the spinning glands on the floor of the buccal cavity.

7. The malpighian tubes are six in number and consist of two sets, each opening into a urinary duct, which in turn opens into the anterior chamber of the ileum.

8. The fore-intestine is formed anteriorly by the proliferation of the integumentary histoblastic discs that develop in the prepupa between eight to ten hours before pupation. Posteriorly it is formed from proliferating histoblastic cells in the region of the cardiac valve. As the histoblastic cells develop the larval oesophageal cells degenerate. This appears to be entirely a chemical process and does not involve the action of any phagocytes. The two columns of histoblastic cells unite and form a muscular wall which also undergoes degeneration.

The formation of an oesophageal diverticulum is traced from its beginning in the 60 hour pupa to its completion in the 384 hour pupa.

9. Just before pupation the larval epithelium of the ventriculus is cast into the lumen and a new epithelial wall produced by the proliferation of the replacement cells which lie

at close intervals along the inner surface of the ventricular wall. The replacement cells of the ventricular epithelium are present in the larva, pupa, and adult. The number is indefinite but they often occur as close as every second to third epithelial cell, or as far apart as every fifth to eight epithelial cell. They are always located at the base of these cells. When single they may be triangular, hemispherical, or spindle- to vase-like in shape. In the median and posterior portions of the ventricular wall, they often occur in clusters or nests.

At pupation the "yellow body" is complete and occupies a large part of the ventricular lumen. Before pupation, however, an anterior and posterior tissue plug has been formed at the cardiac and pyloric valve regions respectively. Thus the contents of the ventriculus can not escape at this stage.

The newly formed epithelial cells of the ventriculus grow, change their form and many pour their entire contents into the lumen. Certain cells become loosened and along with their secretions surround the "yellow body" in the lumen of the organ. This mass of exuviated larval tissue appears to contribute some nourishment to the growing cells and is gradually absorbed, leaving only scattered granular particles remaining. On the opening of the pyloric valve at the 264th hour, the remaining contents of the ventriculus passes into the hind intestine and is stored in the colon. After some further decomposition it becomes the fluid liberated by the adult, shortly after emergence, known as the meconium.

The muscular wall of the mid-intestine also undergoes degeneration and like that of the fore-intestine is formed anew from certain cells known as myeloblasts.

10. The metamorphosis of the hind-intestine begins at the same time as the fore-intestine. Integumentary histoblastic discs proliferate and gradually replace the larval epithelium in the posterior region. Histoblastic cells in the region of the pyloric valve also begin to grow and extend posteriorly and replace the larval epithelium in the anterior region. A narrow ileum is produced and a larger thin walled distensible sac-like colon. An ileo-colic valve is formed and along the wall of the colon six characteristic rectal glands are developed from areas of the proliferating histoblastic cells.

Posterior to the colon is a narrow slightly convoluted rectum or rectal tube. On the opening of the pyloric valve

the contents of the mid-intestine pass into the colon. Further progress is prevented by a chitinous plug that lies in the median and posterior lumen of the anal tube. On eclosion, however, the latter is removed with the exuviation of the larval cuticle, and after a short period of activity some of the intestinal contents are voided as the meconium. Some, however, seem to remain in all specimens and may serve as a source of nutriment to the adult, as the latter does not feed.

11. The spinning glands of *Homaledra* undergo an internal chemical degeneration. Leucocytes from the blood then attack the dead glandular areas and aid in destroying them. The ducts undergo internal changes that result in a great diminution in size, but are not attacked by the leucocytes. They persist in the imago and resemble the typical thoracic glands as described from other forms.

The functional salivary glands undergo the same degeneration that occurs in the spinning glands. They were not found to be present in the adult.

12. The larval urinary duct is completely destroyed and regenerated from proliferating histoblastic cells that form the anterior region of the ileum. The imaginal muscular walls are formed by myoblasts.

A very characteristic internal degeneration takes place in the Malpighian tubes. They are greatly reduced in size and modified in cellular structure but the form and number remain the same as in the larva.

13. A brief comparison of *Homaledra* with other forms is included. Although the writings of other workers show some variations, the present study corroborates the more recent findings. Namely that phagocytosis does not occur in the alimentary canal, but may be instrumental in destroying certain tissues, such as muscles and glands after complete chemical degeneration has taken place. Furthermore, that the digestive tract of the imago is formed from the proliferation of groups of histoblastic discs and histoblastic cells arranged in definite places in the larva. The destruction of the larval cells is brought about by certain chemical changes that produce a typical degeneration and disintegration of their structure, such changes coincident with the proliferation of the new germinal cells.

LITERATURE CITED.

- Balbiani, E. G. 1890. Etudes anatomique et histologique sur le tube digestif de Chrytrops. Arch. de Zool. Exp. 2, Sér. T. VIII.
- Beal, J. A. 1927. The Development of the Proventriculus of *Pityogenes Hopkinsi* Swaine. Ann. Ent. Soc. of America. Vol. XX, No. 4, pp. 522-539.
- Berlese, A. 1901. Osservazioni su fenomeni che avvengono durante la ninfosi degli Insetti metabolici. Rivista Patologia Veget., t. VIII et IX; 1-444.
1913. Intorno alle metamorfosi degli insetti. Estratto dal "Redia," Vol. IX, fasc. 2; 121-136.
- Blanc, L. 1899-91. La tete du Bombyx mori à l'état larvaire; anatomie et physiologie. Extrait du volume des Travaux du Laboratoire d'Études de la Soie années. Lyon, 1891.
- Bordas, L. 1904. Sur les glandes mandibulaires de quelques larves de Lépidoptères. C. R. Soc. Biol., Paris. T. 56: 474-476.
1907. Les glandes salivaires de la mante religieuse. (*Mantis religiosa* L.) Mem. Soc. Zool. France. T. 20.
1911. L'Appareil Digestif et les Tubes de Malpighi des Larves des Lépidoptères. Annales des Sciences Naturelles. Zool. T. XIV; 191-273.
- Cholodkowsky, N. 1887. Sur la morphologie de l'appareil urinaire des Lépidoptères. Archives de Biologie, t. VI, pp. 497-514.
- Comstock, J. H. 1925. An Introduction to Entomology.
- Creighton, J. T. 1929. The Biology and Life History of the Palm-Leaf Skeletonizer (Palm-leaf miner) *Homaledra sabalella* Chambers. (Unpublished mss. Dept. Ent. & Plant Path., University of Florida).
- Deegener, P. 1904. Die Entwicklung des Darmcanals der Insecten während der Metamorphose. Zool. Jahrb. Abtheilung für Anatomie und Ontogenie der Thiere. Zwanzigster Band, Heft. 4.
1908. Die Entwicklung des Darmcanals der Insecten während der Metamorphose. Zool. Jahrb. Abtheilung für Anatomie und Ontogenie der Thiere. Sechszwanzigster Band, Heft. 1.
- Dufour, L. 1846. Études anatomiques et physiologiques sur une Mouche. Mem. des Savants étrangers. Paris T. IX.
- Folson, J. W. and Wells, M. N. 1906. Epithelial degeneration, regeneration and secretion in mid-intestine of Collembola. Univ. of Ill., Studies, Vol. II, No. 2.
- Frenzel, J. 1882. Ueber Bau und Thatigkeit des Verdauungskanal der Larve des *Tenebrio molitor* und Berücksichtigung andere Arthropoden. B. E. Z. XXVI, pp. 267-316.
1885. Einiges über den Mitteldarm der Insecten, sowie Epithelregeneration. Arch. mikr. Anat. XXVI, pp. 229-306.
- Ganin, M. 1876. The Development and post-embryonic development of Insects (In Russian). Warsaw. Summary by Hoyer in Zeit. f. wiss. Zool., Bd. 28: 386-389. 1877.
- Gilson, G. 1890. La soie et les appareils séricigènes. I. Lépidoptères. La Cellule, 6: 115-182.
- Haseman, L. 1910. Structure and Metamorphosis of Alimentary Canal of larva of *Psychoda alternata* Say. Ann. Ent. Soc. America, Vol. III, No. 4, pp. 277-313.
- Neim, F. E. 1876. Ueber die Spinndrüsen der Lepidopteren. Zeitschr. f. wiss. Zool., bd. 26: 434-469.
- Henseval, M. 1897. Les glandes à essence du *Cossus ligniperda*. La Cellule. Vol. XII.
- Herold, M. J. D. 1815. Entwicklungsgeschichte der Schmetterlinge, anatomisch und physiologisch. (Dissertation presented at Marburg, March, 1815.)

- Hewitt, C. G.** 1907. The structure, development and bionomics of the house-fly, *Musca domestica* L. Part I. The anatomy of the fly. The Quarterly Journal of Microscopical Science. Vol. 51, Part 3: 395-448.
- Hufnagel, A.** 1912. Metamorphose de tubes de Malpighi de l'*Hyponomena padella* L. Compt. Rend. Soc. Biol. T. LXXIII.
- Hurst, C. H.** 1890. The Pupal Stage of *Culex*. Inaug. dissert. (Manchester) for Univ. of Leipzig.
- Ikeda, E.** 1913. Kiaki no Hentai Ron. (In Japanese). (Reviewed by Ito, 1920, in English.)
- Imms, A. D.** 1907. Blood sinus in Dipterous larvae. Jour. Hyg., p. 301.
1925. A General Textbook of Entomology. London, pp. 1-698.
- Ito, H.** 1920. On the Metamorphosis of the Malpighian Tubes of *Bombyx Mori* L. Bull. of Imperial Tokyo Sericultural College, Japan, Vol. I, No. 5; pp. 105-118.
- Karawarew, W.** 1897. Die nachembryonale Entwicklung von *Lasius flavus*. Zeitschr. f. wiss. Zool. LXIV.
- Kingsbury, B. F. and Johannsen, O. A.** 1927. Histological Technique.
- Korotneff, A.** 1892. Histolyse und Histogenese des Muskelgewebes bei der Metamorphose der Insecten. Biol. Centrbl., 5.
- Kowalevsky, A.** 1885. Beiträge zur nachembryonalen Entwicklung der Musciden. Zool. Anz., jhg. 8: 98-103, 123-128, 153-157.
- Lowne, B. T.** 1890-95. The Anatomy, Physiology, Morphology, and Development of the Blow-fly. 2 vol. London.
- Lyonet, P.** 1762. Traité anatomique de la Chenille qui ronge le bois du Saule. Amsterdam.
- Malpighi, M.** 1669. Dissertatio epistolica de Bombyce. Londres.
- Mansour, K.** 1927. Development of the larval and adult mid-gut of *Calandra oryzae* (Linn.). The Rice Weevil. Quart. Journ. of Microscopical Science, new series, Vol. 71: pp. 314-352.
- Matheson, R.** 1912. The structure and metamorphosis of the fore-gut of *Corydalus cornutus* L. Jour. of Morphology, Vol. 23, No. 4: 581-615.
- McDunnough, J.** 1909. Über den Bau des Darms und seiner Anhangs von *Chrysopa perla* L. Archiv. für. Naturgeschichte. 75. Jahrg. I Bd. 3 Heft, s. 313-360.
- Metalnikoff.** 1908. Recherches experimentales sur les chenilles, de *Galleria mellonella* arch. d. Zool. expér. T. 8, N. 8, quatr. sér.
- Miall, L. C. and Denny, A.** 1886. The Structure and Life History of the Cockroach. London.
- Miall, L. C. and Hammond, A. K.** 1900. The Structure and Life History of the Harlequin fly (*Chironomus*).
- Mobusz, A.** 1897. Über den Darmkanal der Anthrenus Larve. Arch. für Naturgesch. Jg. 63, Bd. I.
- Muller, K.** 1927. Beiträge zur Biologie, Anatomie, Histologie und inneren Metamorphose der Thripslarven. Zeitschr. f. wiss. Zool., 130: 251-303.
- Needham, J. G.** 1897. The digestive epithelium of dragon-fly nymphs. Zool. Bull. 1, pp. 103-113.
- Oertel, E.** 1928. Metamorphosis in the Honey Bee. Ph. D. Thesis, Cornell Univ. (unpublished ms.).
- Packard, A. S.** 1898. A Text Book of Entomology.
- Perez, C.** 1902. Contribution à l'étude des Metamorphoses. Bull. Scient. France et Belgique, t. XXXVII: 195-427.
1910. Recherches histologiques sur la métamorphose des Muscides (*Calliphora erythrocephala* Mg.). Arch. Zool. Exper. et Gen., t. IV: 1-274.
1911. Observations sur l'Histolyse et l'histogenese dans la métamorphose des Vespides (*Polistes gallica* L.). Mémoires de l'Académie royale de Belgique, Deuxieme série, t. III: 1-99.

- Poyarkoff, E. 1910. Recherches histologique sur la métamorphose d'un Coleoptère. Archives Anatomie Microscopique, XII: 333-472.
- Reaumur. 1734. Mémoires pur servir à l'histoire des Insectes.
- Rengel, 1896. Ueber die Veränderungen des Darmepithels bei *Tenebrio molitor* während der Metamorphose. Zeitschr. f. wiss. Zool. Bd. LXII.
- Samson, K. 1908. Ueber das Verhalten der Vasa Malpighi und die excretorische Funktion der Fettzellen während der Metamorphose von *Heterogenea limacodes* Hufn. Zool. Jahrb. Abt. Anat., Band. XXVI: 403-422.
- Schroder, C. 1912. Handbuch der Entomologie. Band. 1. Jena.
- Seurat, L. G. 1869. Contribution à l'étude des Hymenopteres. Entomophages. Ann. Sc. Nat. Zool. 8, serie t, x.
- Snodgrass, R. E. 1924. Anatomy and Metamorphosis of the Apple Maggot, *Rhagoletis pomonella* Walsh. Jour. Agr. Res., Vol. XXVIII, No. 1, p. 26.
1925. Anatomy and Physiology of the Honey Bee.
- Spuler, A. 1908. Die Schmetterlinge Europas 1. Band, s: 26.
- Swammerdam. 1685. Biblia naturae; parue à Leyde.
- Tanaka, T. 1924. The Alimentary Canal of the Larva of *Simulium pictipes* Hagen. (Unpublished ms., Dept. Ent., Cornell Univ.).
- Tiegs, O. W. 1922. Researches on the Insect Metamorphosis. Trans. and Proc. of Royal Society of South Australia, Vol. XLVI, pp. 319-527.
- Tietz, H. M. 1923. Anatomy of the digestive system of the Carolina Locust (*D. carolina* L.). Ann. Ent. Soc. America, Vol. 16, pp. 256-273.
- Thompson, M. T. 1905. Alimentary Canal of the Mosquito. Proc. of Boston Soc. of Nat. Hist., Vol. 32, No. 6, pp. 145-202.
- Trappmann, W. 1923. Die Bildung der peritrophischen Membrane bei *Apis Mellifica* L. Archiv. fur Bienenkunde, Sechtes Heft., s. 204-212.
- Van Gehuchten, A. 1890. Recherches histologiques sur l'appareil digestif de *Ptychoptera contaminata* (Dipt.). La Cellule, t. VI, fasc. 1er.
- Van Rees, J. 1888. Beitrage zur Kenntniss der inneren Metamorphose von *Musca vomitaria*. Zool. Jahrb. Anat. 5, 3.
- Vaney, C. 1902. Contributions à l'étude des larves et des Metamorphoses des Diptères. Ann. Univ. Lyon, (2) L. Sc. fasc. 9.
- Verson, E. 1905. Zur Entwicklung des Verdauungskanals bei *Bombyx mori*. Zeitschr. f. wiss. Zool. B. 82, s. 523-600.
- Verson and Bisson. 1891. Cellule glandulari ipostigmatiche nel *Bombyx mori*. Bull. Ent. Ital. 23.
- Volnov, N. D. 1898. Recherches physiologiques sur l'appareil digestif et le tissu adipeux des larves des Odonates. Bull. Soc. Sc. Bucarest, Vol. VII.
- Weismann, A. 1864. Die nachembryonale Entwicklung der Musciden. Zeit. f. wiss., Zool., Bd. 14, pp. 187-336.

LIST OF ABBREVIATIONS.

an.....anus	mand. gl...mandibular gland
a. t.....anal tube	max. gl...maxillary gland
b.....bristle	md.....mandible
b. m.....basement membrane	m. int.....mid-intestine
br.....brain	m. v. e. c...mass of ventricular epithelial cells
card. v...cardiac valve	my.....myeloblast
chi. i.....chitinous intima	nuc.....nucleus
chi. pl....chitinous plate	
c. m.....circular muscle	o.....orifice
col.....colon	oes.....oesophagus
cr.....crystals	oes. div...oesophageal diverticulum
	oes. epith. oesophageal epithelium
d. l. c.....degenerating larval cells	p. cut.....pupal cuticula
d. m.....degenerating muscle	p. d. m....pharyngeal dilator muscle
ec. c. m....ectal circular muscle	per. m....peritoneal membrane
en. c. m....ental circular muscle	ph.....pharynx
epid. c....epidermal cell	ph. epith. pharyngeal epithelium
epith.....epithelium	p. m.....peritrophic membrane
epith. c....epithelial cell	prov.....proventriculus
	py. v.....pyloric valve
gl. e. c....glandular epithelial cells	r. c.....replacement cell
h. int.....hind intestine	rect.....rectum
hist. d....histoblastic disc	rect. gl...rectal gland
hist. c....histoblastic cell	
i. epith. c...imaginal epithelial cell	sal. d.....salivary duct
i. hist. c...integumentary histoblastic cell	sal. gl....salivary gland
i. hist. d...integumentary histoblastic disc	s.....secretion
il.....ileum	s. b.....striated border (or striated hem)
il. col. v...ileo-colic valve	s. e. c....secretion from epithelial cells
il. v.....ileal valve	s. m....sphincter muscle
i. s. z.....inner striated zone	sup. g.....supra-oesophageal ganglion
	s. w.....superior wall
l. c.....larval cell	t. i.....tunica intima
l. cut.....larval cuticula	t. p.....tissue plug
l. epith....larval epithelium	t. pr.....tunica propria
leu.....leucocyte	ur. d.....urinary duct
l. o. c....larval oesophageal cell	
l. m.....longitudinal muscle	v.....valve
lu.....lumen	vent.....ventriculus
lw.....lateral wall	v. epith...ventricular epithelium
m.....muscle	
malp. t...Malpighian Tubes	w. prov....wall of proventriculus
	y. b.....yellow body

DESCRIPTION OF PLATES.

PLATE I.

- Fig. 1. Digestive system of active, feeding, mature larva of *Homaledra*. ($\times 9$).
Fig. 2. The same, from another specimen of the same age. ($\times 9$).
Fig. 3. Portion of cross-section through larval pharynx to show structure of lateral and dorsal walls. Note recurved ridges with bristle-like projections on lateral wall, and chitinous plate on superior wall. ($\times 650$).
Fig. 4. Longitudinal section through larval pharynx. Note recurved bristles on ridges projecting into the pharyngeal lumen, and a few of the chitinous plates on the superior wall. ($\times 450$).
Fig. 5. Section through union of larval pharynx and oesophagus. Note the transition between the multinucleated pharyngeal epithelium and the oesophageal epithelium. ($\times 400$).

PLATE II.

- Fig. 6. Longitudinal section through larval oesophagus and proventriculus. Note cardiac valve formed at junction of proventriculus and mid-intestine. ($\times 250$).
Fig. 7. Longitudinal section through wall of larval proventriculus. ($\times 400$).
Fig. 8. Longitudinal section of triangular muscular area at junction of cardiac valve and wall of the ventriculus. ($\times 400$).
Fig. 9. Cross section of muscular wall of the larval ventriculus (mid-intestine). ($\times 500$).
Fig. 10. Epithelial cells from anterior region of larval mid-intestine. Note that some of the cells are in process of secretion, also the presence of small histoblastic cells along the basement membrane. ($\times 500$).

PLATE III.

- Fig. 11. Epithelial cells from median region of larval mid-intestine. ($\times 550$).
Fig. 12. Epithelial cells from posterior region of larval mid-intestine. Note denser character of epithelial cells; also histoblastic discs. ($\times 550$).
Fig. 13. Longitudinal section through posterior region of larval mid-intestine and anterior region of the ileum. Note pyloric valve and ileal valve. ($\times 150$).
Fig. 14. Longitudinal section through one-half of the pyloric valve. Note cluster of histoblastic cells and adjacent enlarged glandular-like epithelial cells which make up the anterior or frontal wall of the ileum. ($\times 500$).
Fig. 15. Longitudinal section through pyloric valve of the larva, showing valve flattened out, while digestive tract is filled with food material. ($\times 175$).

PLATE IV.

- Fig. 16. Longitudinal section through ileal valve of larva. ($\times 600$).
Fig. 17. Cross section of alimentary canal in region of ileal valve (larva). ($\times 125$).
Fig. 18. Part of the wall of the same enlarged. ($\times 600$).

PLATE V.

- Fig. 19. Epithelial cells lining the median region of the larval ileum. Longitudinal section. ($\times 250$).
Fig. 20. Cross section through posterior region of ileum (larva). Note the folds in the epithelial wall. ($\times 125$).
Fig. 21. Portion of the same enlarged. ($\times 600$).

PLATE VI.

- Fig. 22. Longitudinal section through the posterior portion of the hind-intestine (larva). ($\times 125$).
Fig. 23. Cross section through posterior region of larval colon, (walls not distended). ($\times 250$).

PLATE VII.

- Fig. 24. One of the spinning glands from a larva of *Homaledra*. Note the character of the loop in the glandular portion. ($\times 10$).
Fig. 25. The same, but from another larva to show the double looping of the glandular portion. ($\times 10$).
Fig. 26. Union of salivary glands at base of ligula, in the anterior median floor of the buccal cavity. Note portion of maxillary glands on either side. ($\times 150$).
Fig. 27. Mandibular gland from larva. Longitudinal section. ($\times 150$).
Fig. 28. Longitudinal section through glandular portion of mandibular gland of larva. ($\times 400$).

PLATE VIII.

- Fig. 29. Longitudinal section through anterior region of prepupa. Note that the histoblastic discs of the integument have begun to proliferate and the germinal layer has drawn away from the larval cuticula. ($\times 175$).

PLATE IX.

- Fig. 30. Longitudinal section showing proliferation of integumentary histoblastic cells at edge of larval oesophagus. ($\times 450$).
Fig. 31. The same showing extensive growth of histoblastic cells to form a new integumentary cells. ($\times 450$).
Fig. 32. Longitudinal section in region of cardiac valve about 6 hours before pupation. Note proliferation of the histoblastic discs and beginning of the tissue plug. ($\times 400$).

PLATE X.

- Fig. 33. Longitudinal section through region of cardiac valve just after pupation. Note complete tissue plug across anterior end of ventriculus. ($\times 400$).
Fig. 34. Anterior region of oesophagus at time of pupation. Note that the integumentary histoblastic cells have completely lined the new cuticle and have extended along the anterior portion of the oesophageal lumen. ($\times 500$).
Fig. 35. Longitudinal section through oesophagus at its completion (72 hours after pupation). ($\times 200$).

PLATE XI.

- Fig. 36. Oesophageal diverticulum in 60 hour pupa. ($\times 125$).
Fig. 37. Longitudinal section through region of oesophageal diverticulum and cardiac valve in 60 hour pupa. ($\times 250$).
Fig. 38. Oesophageal diverticulum in 96 hour pupa. ($\times 125$).
Fig. 39. The same in 120 hour pupa. ($\times 125$).
Fig. 40. Longitudinal section through junction of oesophagus and oesophageal diverticulum in 120 hour pupa. ($\times 250$).
Fig. 41. Oesophageal diverticulum in 168 hour pupa. ($\times 125$).

PLATE XII.

- Fig. 42. Longitudinal section through the anterior region of the oesophageal diverticulum; also union of the oesophagus and ventriculus. Note the thick walled, multinucleated structure joining the oesophagus with the ventriculus. ($\times 450$).
- Fig. 43. Digestive tract dissected from adult moth of *Homaledra sabalella*. ($\times 8$).
- Fig. 44. The same from another specimen. ($\times 8$).
- Fig. 45. The same from another specimen. Note that oesophageal diverticulum and ventriculus are inflated with air. ($\times 8$).
- Fig. 46. The same from another specimen. ($\times 8$).
- Fig. 47. Longitudinal section through pyloric valve in 6 hour pupa. Note the formation of the tissue plugs and the proliferation of the histoblastic cells. ($\times 400$).

PLATE XIII.

- Fig. 48. Cross section through ventriculus to show separation of larval epithelial cells from basement membrane. This is the beginning of the formation of the "yellow body." ($\times 500$).

PLATE XIV.

- Fig. 49. Cross section through "yellow body" and portion of wall of ventriculus (at time of pupation). ($\times 400$).
- Fig. 50. Epithelial cells from wall of ventriculus in 24 hour pupa. ($\times 475$).
- Fig. 51. Epithelial cells from wall of ventriculus in 36 hour pupa. ($\times 475$).
- Fig. 52. Longitudinal section through pyloric valve in 144 hour pupa. Note internal degeneration of the posterior tissue plug. ($\times 400$).
- Fig. 53. Opening of pyloric valve in 264 hour pupa. Note contents of ventriculus passing into the hind-intestine. ($\times 400$).

PLATE XV.

- Fig. 54. Cross section through the anterior portion of the ventriculus in the 348 hour pupa to show nature of epithelial cells. ($\times 350$).
- Fig. 55. Cross section through the median region of the ventriculus in the 348 hour pupa. ($\times 350$).
- Fig. 56. Cross section through the anterior region of the ventriculus just before eclosion. Note that the lumen may be compressed or expanded with air. This is the characteristic ventricular epithelium of the adult moth. ($\times 350$).

PLATE XVI.

- Fig. 57. Longitudinal section through posterior end of hind-intestine about 14 hours before pupation. Note the proliferation of the integumentary histoblastic cells. ($\times 450$).
- Fig. 58. Longitudinal section through portion of the ileum 5 hours before pupation. Note that degeneration processes have begun in the circular muscles. ($\times 450$).

PLATE XVII.

- Fig. 59. Cross section in region of ileum in 16 hour pupa. Note that the muscle layers are dead and numerous leucocytes have collected about them. ($\times 500$).
- Fig. 60. Longitudinal section through the hind-intestine, showing the slight dilation of the lumen and the modified arrangement of the histoblastic cells. This marks the beginning of the large intestine (colon). ($\times 150$).
- Fig. 61. Longitudinal section through the ileo-colic valve at time of its origin (120 hour pupa). ($\times 500$).
- Fig. 62. The same, somewhat later. ($\times 500$).
- Fig. 63. The same, completed, (216 hour pupa). ($\times 500$).

PLATE XVIII.

- Fig. 64. Longitudinal section through the posterior region of the hind-intestine just after the formation of the ileo-colic valve. ($\times 75$).
 Fig. 65. Longitudinal section through the colon at time of origin of rectal glands (120 hour pupa). ($\times 500$).
 Fig. 66. Longitudinal section through rectal glands in 144 hour pupa. ($\times 500$).
 Fig. 67. The same, of similar age, from another specimen. ($\times 500$).
 Fig. 68. The same, from 168 hour pupa. The rectal glands are completely developed in this stage. ($\times 500$).

PLATE XIX.

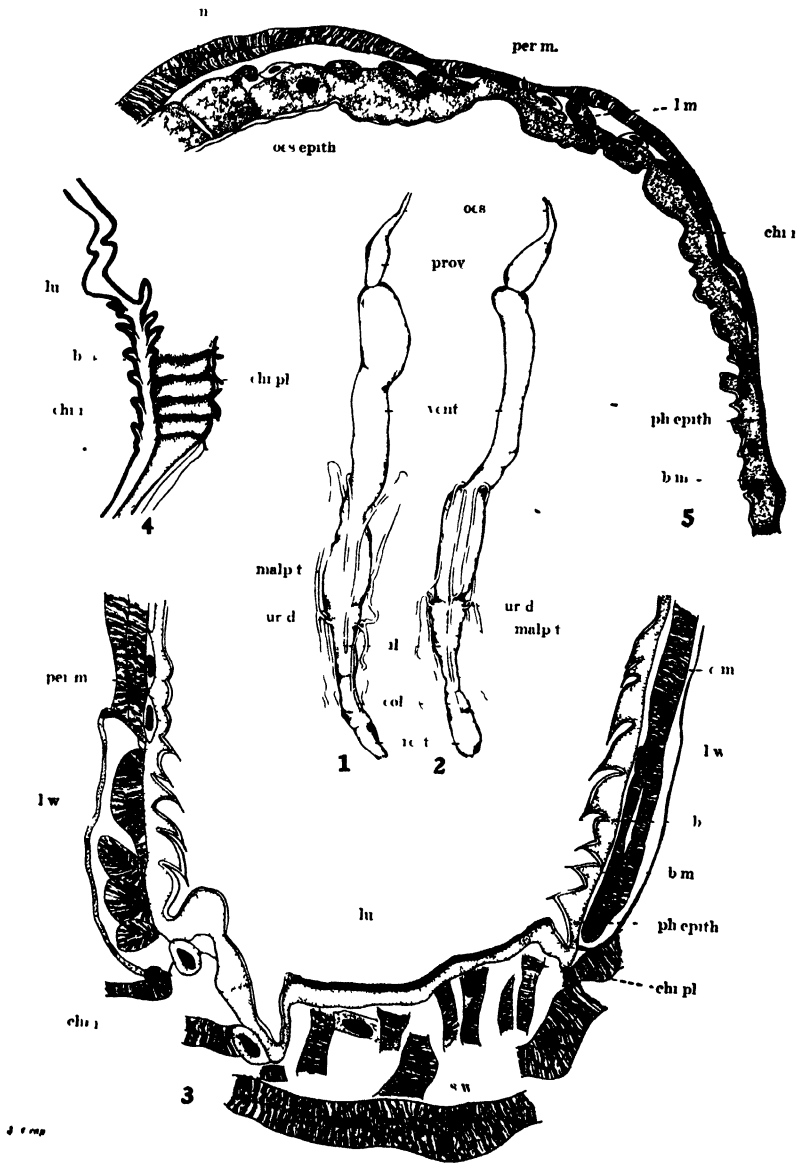
- Fig. 69. Longitudinal section through the posterior region of alimentary canal shortly after the opening of the pyloric valve in the 264 hour pupa. Note that the former contents of the ventriculus have passed into the enlarged colon, but is retained in the latter by folds in the wall of the rectal tube and also by a chitinous plug. ($\times 85$).
 Fig. 70. Longitudinal section through median region of spinning gland to show nature of secreting cells. ($\times 375$).
 Fig. 71. Longitudinal section through spinning gland in secretory stage. ($\times 200$).
 Fig. 72. Surface view of cell from spinning gland to show nature of nucleus. ($\times 360$).

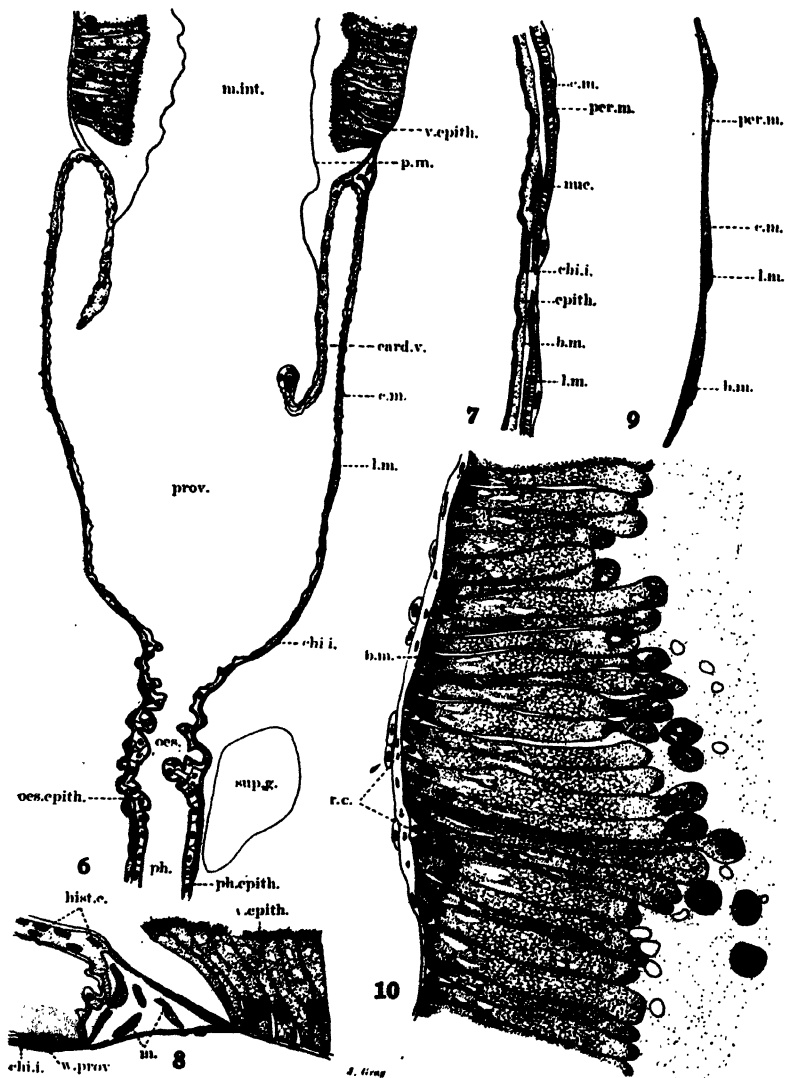
PLATE XX.

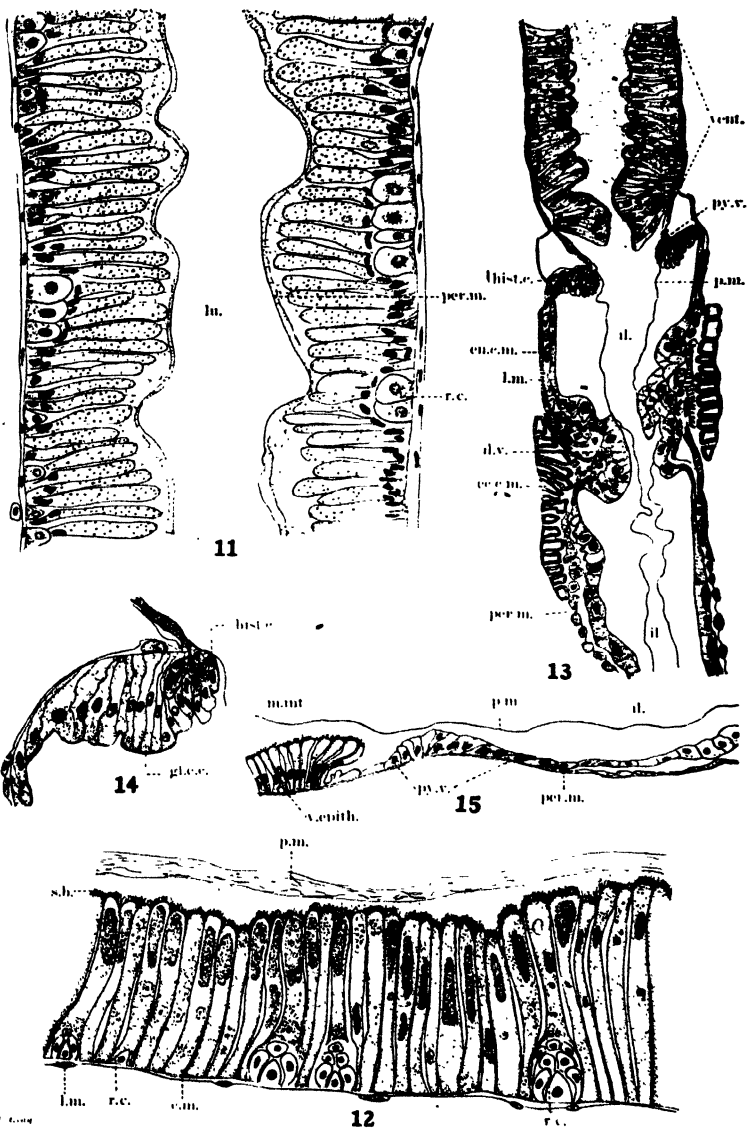
- Fig. 73. Longitudinal section through median region of spinning glands at time of pupation. ($\times 500$).
 Fig. 74. Cross section through anterior region of salivary glands in 12-18 hour pupa. ($\times 375$).
 Fig. 75. Longitudinal section through the same. ($\times 375$).
 Fig. 76. Longitudinal section through the glandular region of the spinning gland in 12-18 hour pupa. Note that the nuclei have begun to disintegrate and small vacuoles appear throughout the cytoplasm. ($\times 400$).
 Fig. 77. Longitudinal section through the spinning gland in 24 hour pupa. Disintegration is progressing rapidly in this stage and leucocytes have begun to attack the periphery of the tunica propria. ($\times 500$).

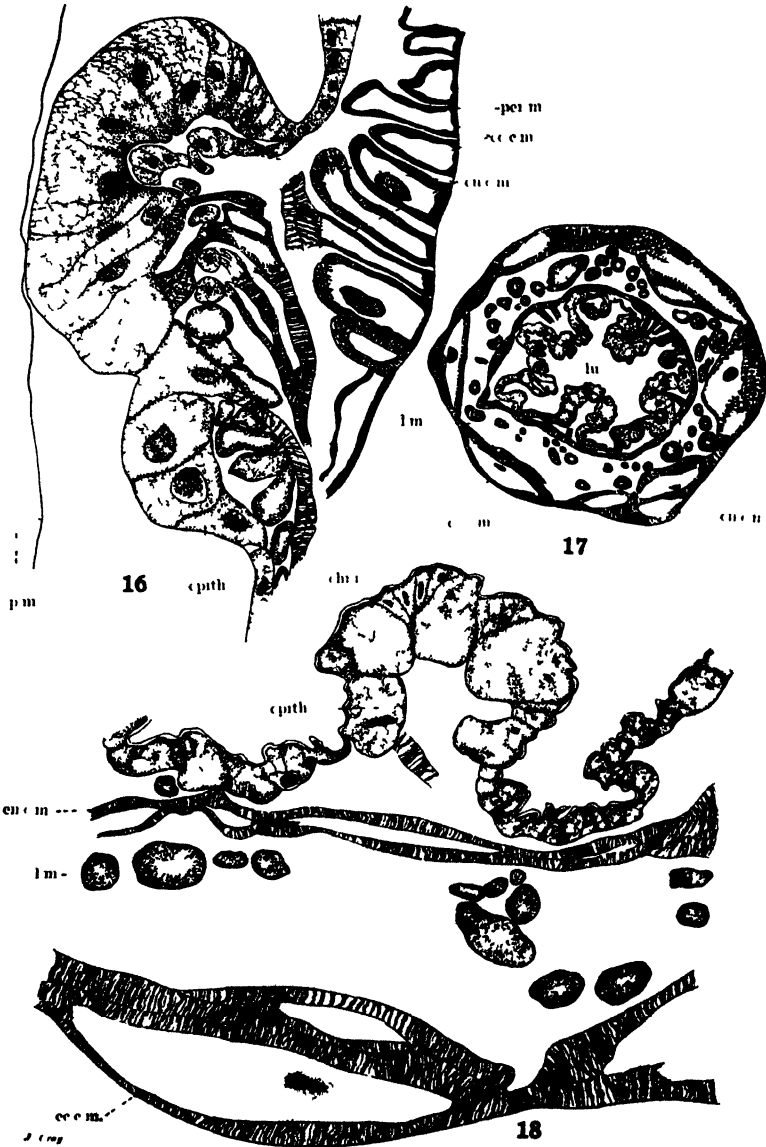
PLATE XXI.

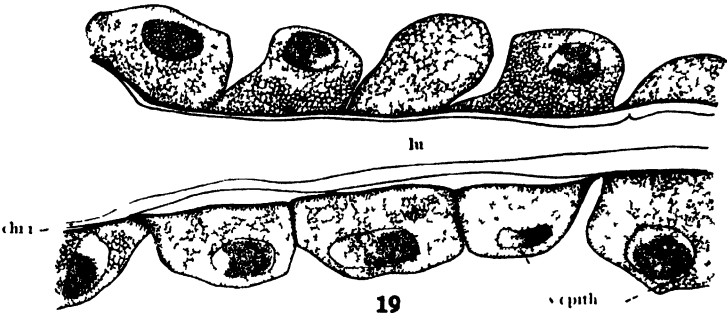
- Fig. 78. Longitudinal section through salivary duct in 24 hour pupa. ($\times 350$).
 Fig. 79. Longitudinal section through spinning gland in 30 hour pupa. Phagocytes are active throughout the dead tissue of the gland at this stage. ($\times 450$).
 Fig. 80. Longitudinal section through a portion of the thoracic gland. ($\times 350$).
 Fig. 81. Longitudinal section of Malpighian tube to show surface view, (larva). ($\times 300$).
 Fig. 82. Longitudinal section through secreting Malpighian tube of larva. ($\times 300$).
 Fig. 83. Cross section through the same. ($\times 300$).
 Fig. 84. Cross section through distended Malpighian tube. Note crystal-like deposits in the lumen. ($\times 400$).
 Fig. 85. Malpighian tube from pupa, 3 hours before pupation. ($\times 350$).
 Fig. 86. Longitudinal sections through Malpighian tubes at the time of pupation. ($\times 350$).
 Fig. 87. Longitudinal section through urinary duct of larva. ($\times 375$).
 Fig. 88. Longitudinal section through neck of urinary duct between second and third hour after pupation. Note the proliferation of the histoblastic cells. ($\times 500$).
 Fig. 89. Cross section of orifice between urinary duct and anterior chamber of the ileum, just after the proliferation of the histoblastic cells, (3-5 hours after pupation). ($\times 450$).







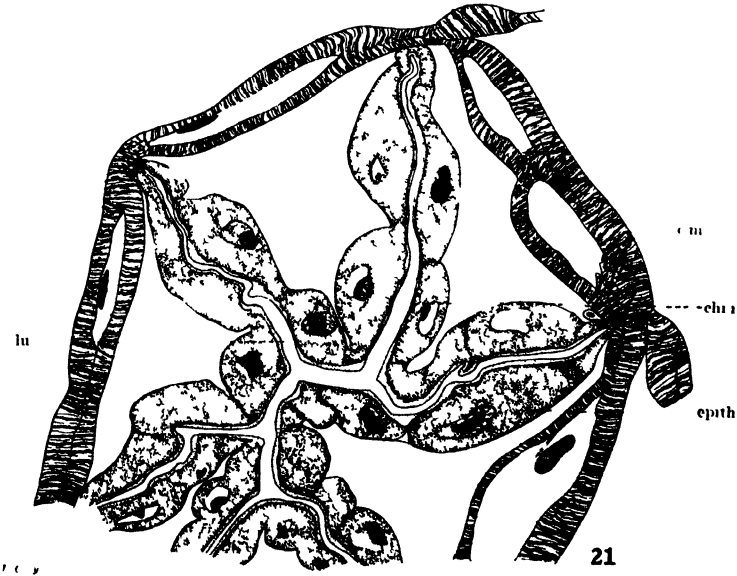




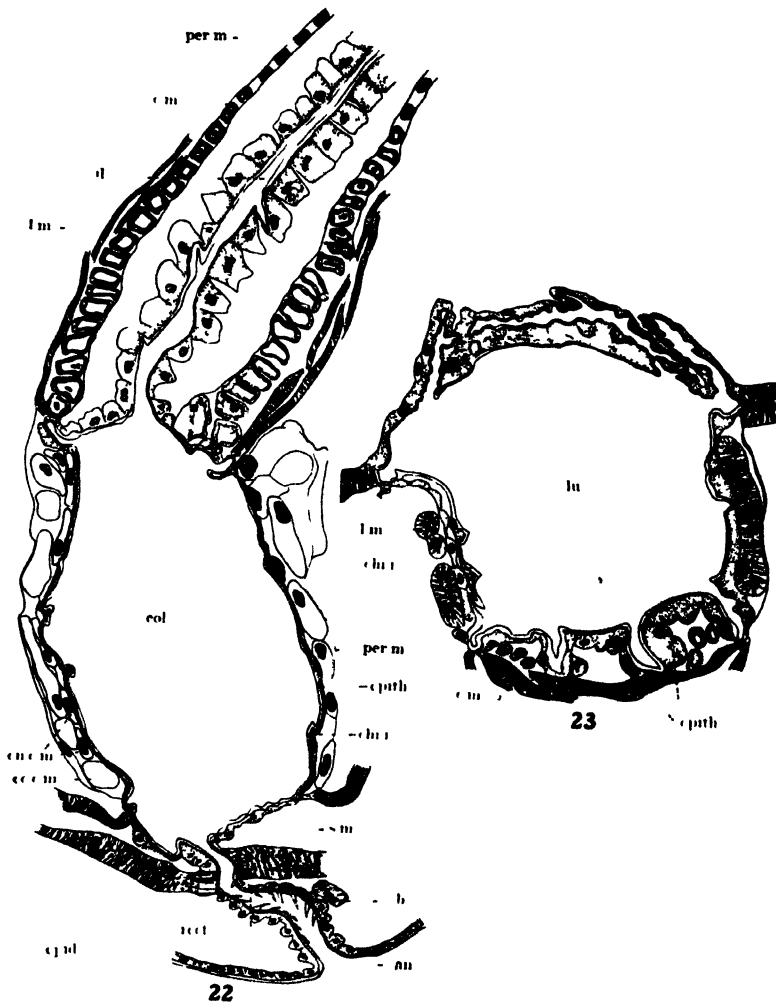
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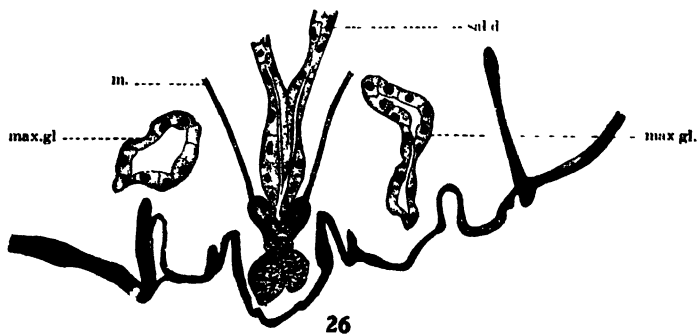
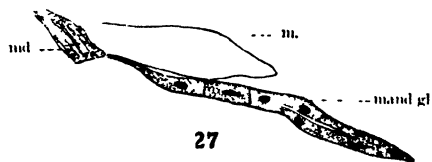
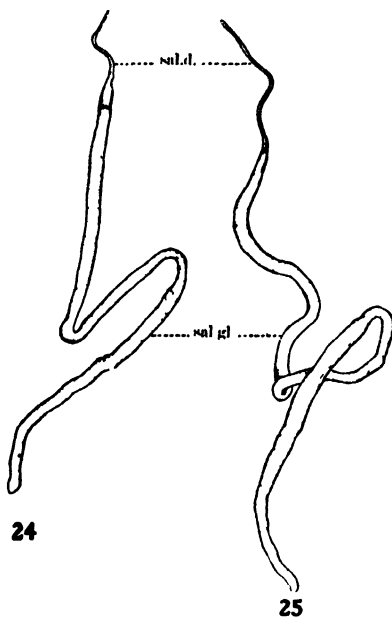


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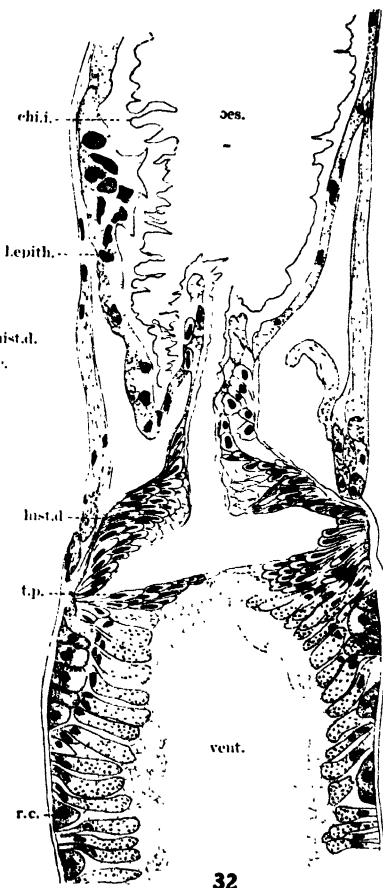
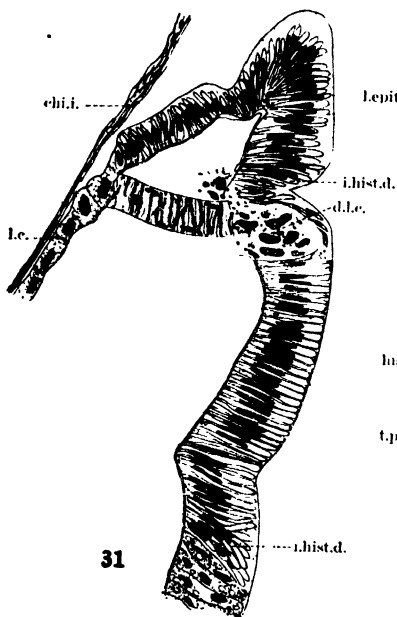
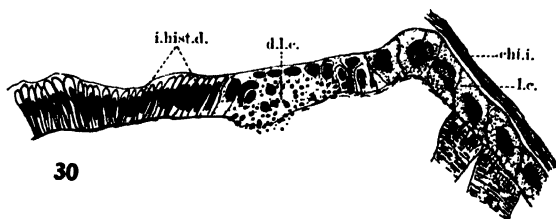


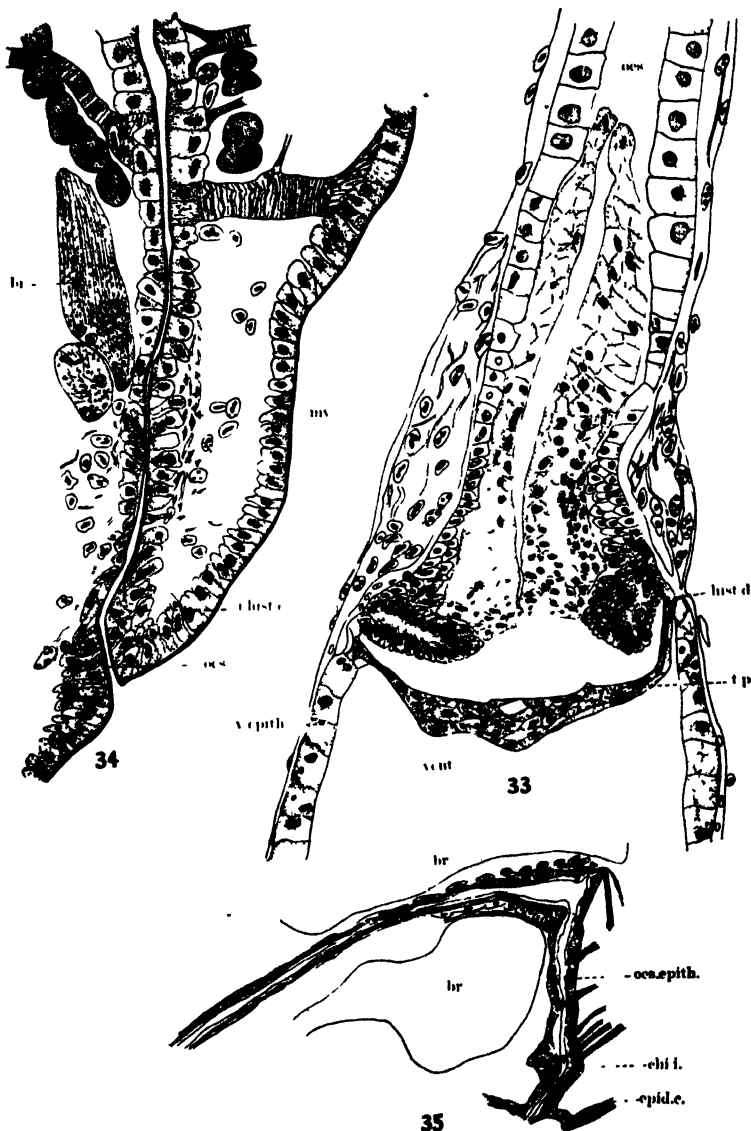
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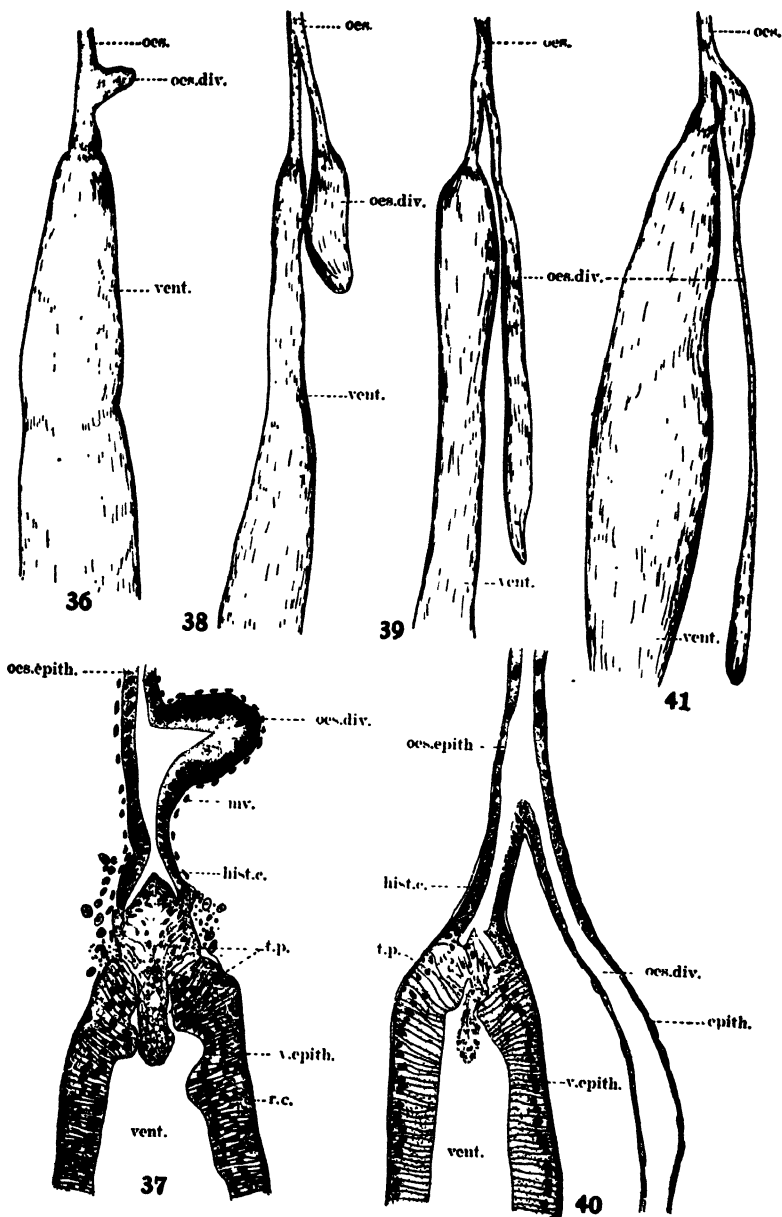


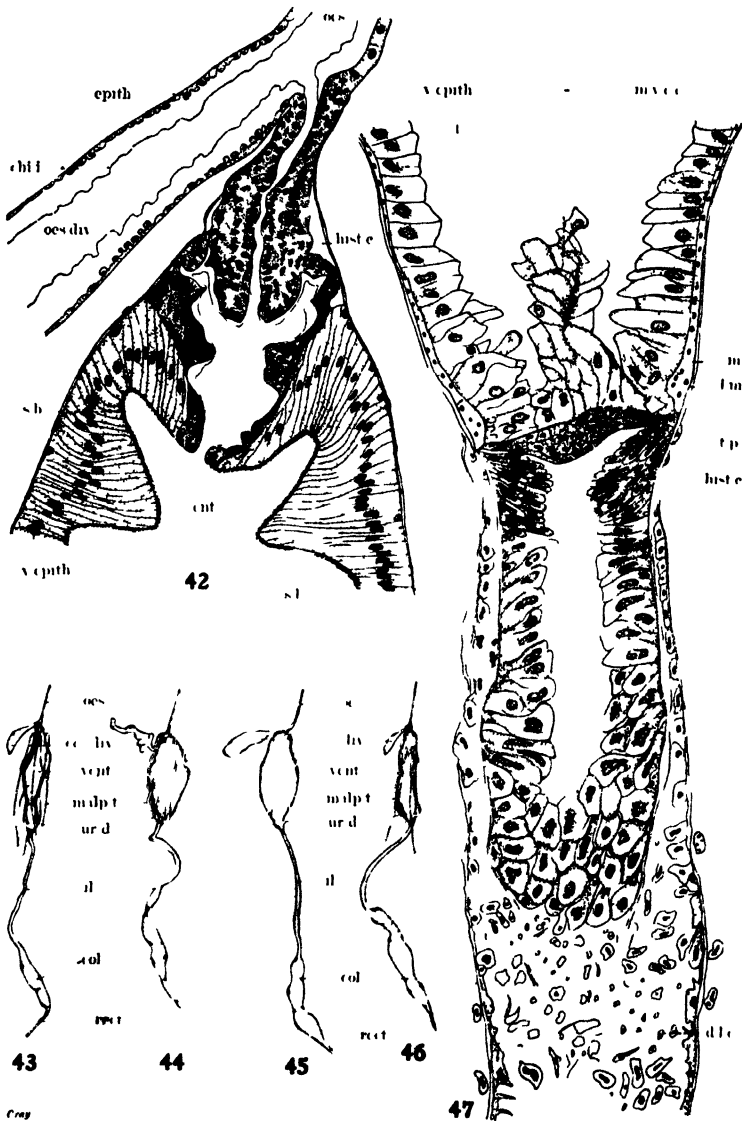






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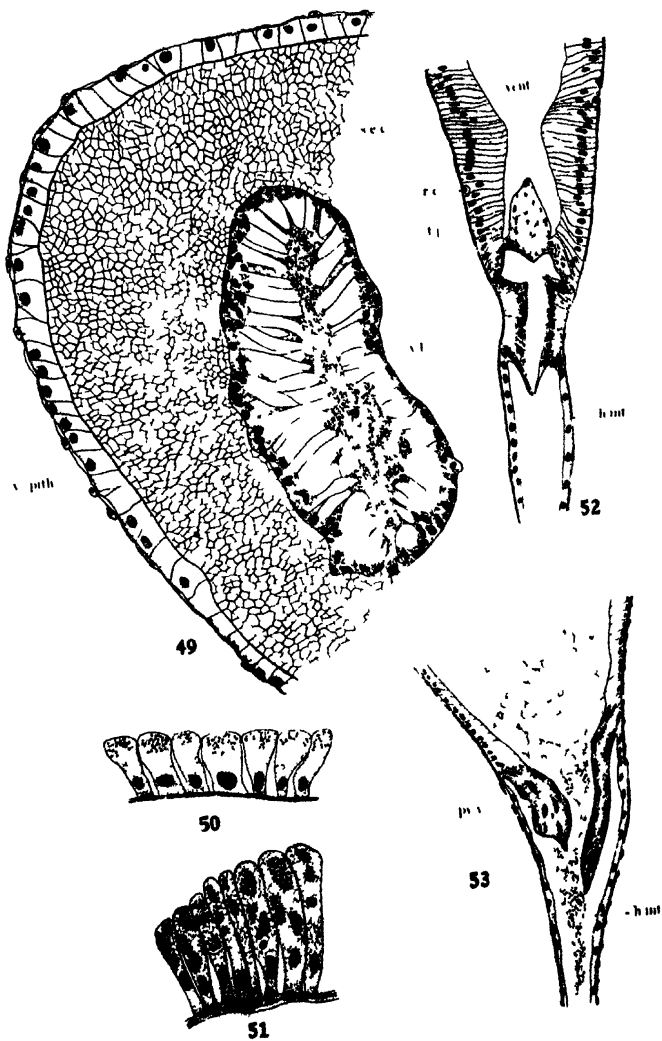


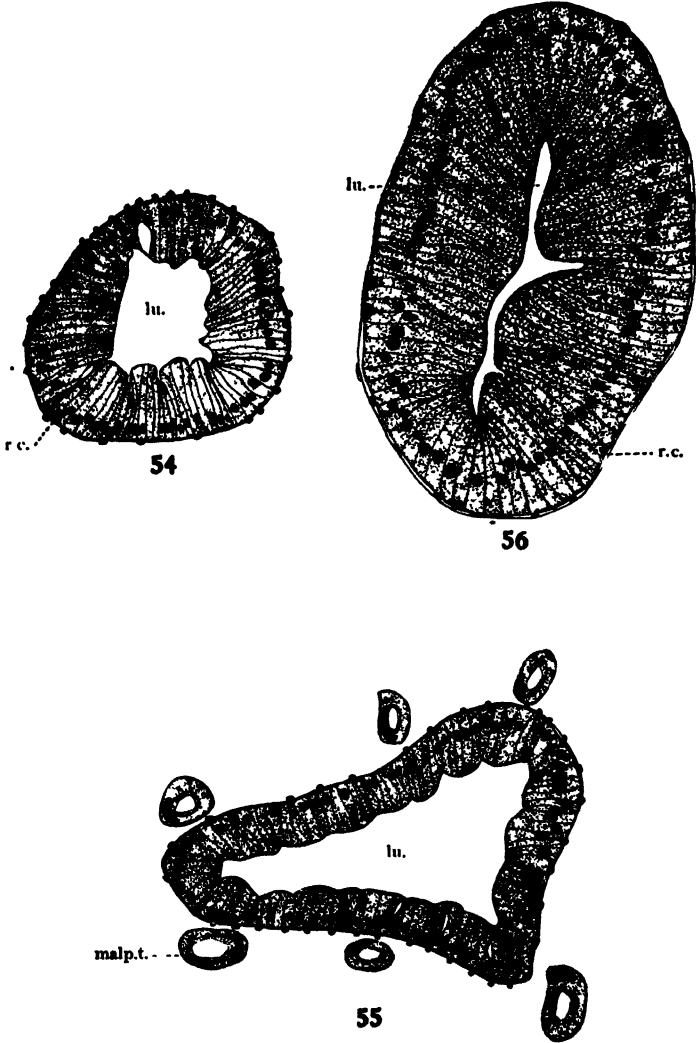


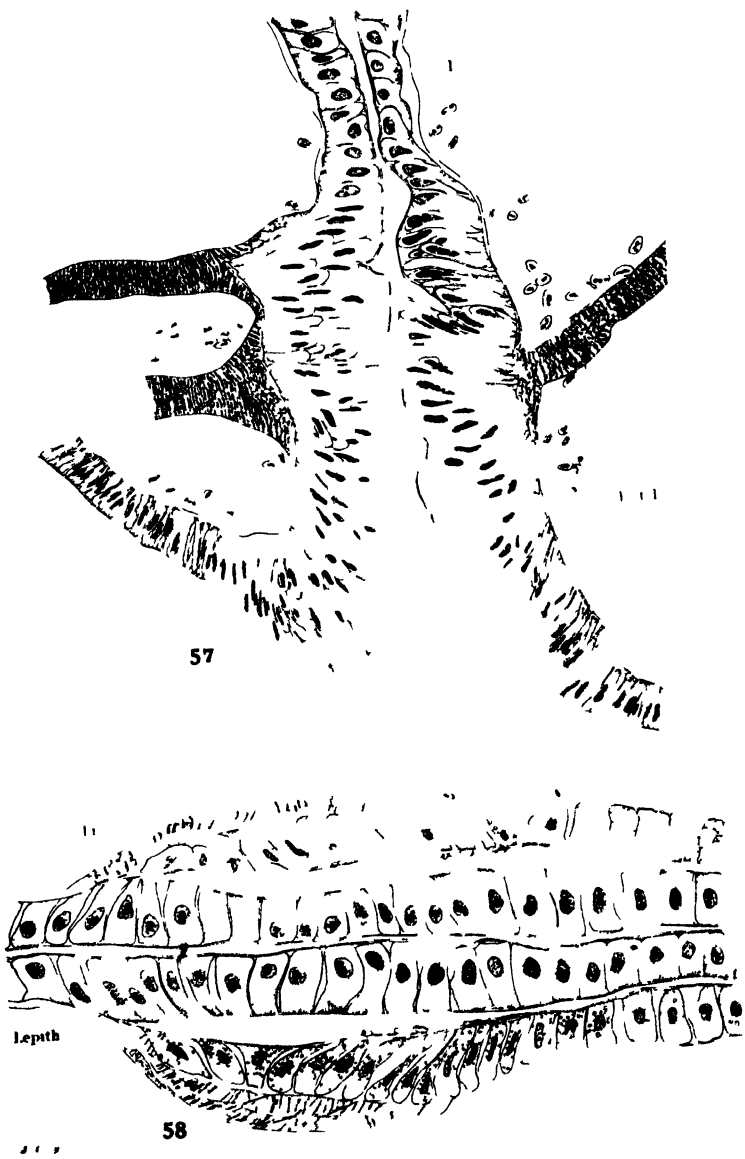
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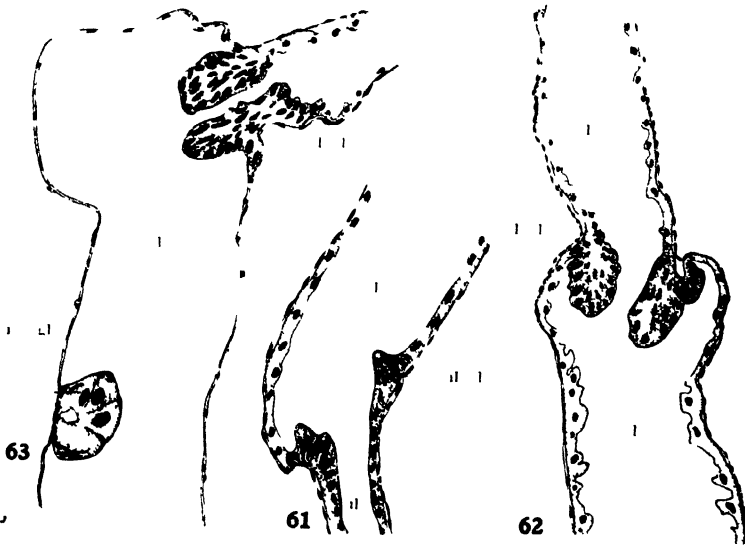
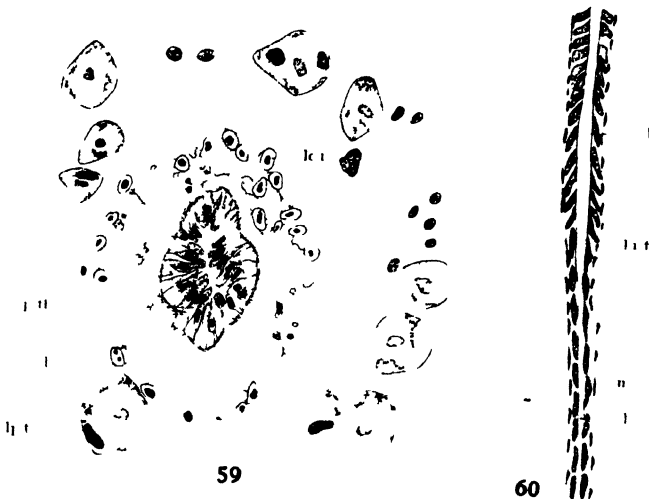


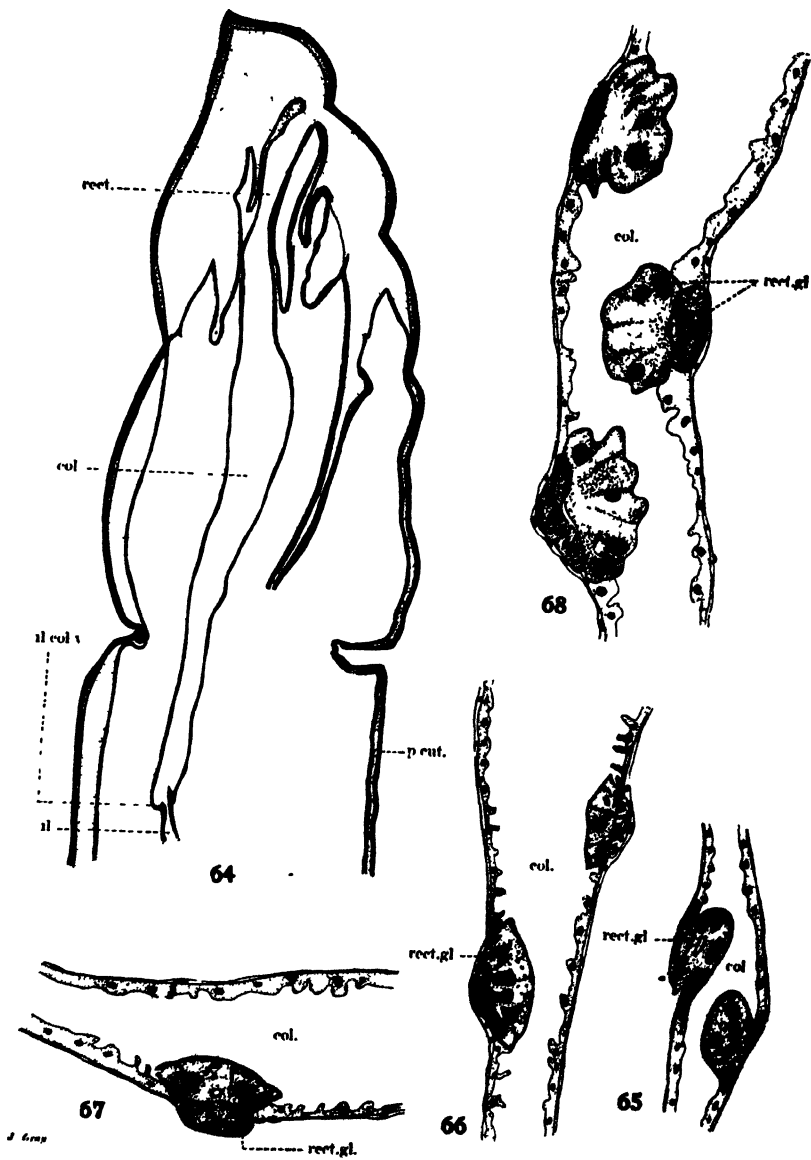
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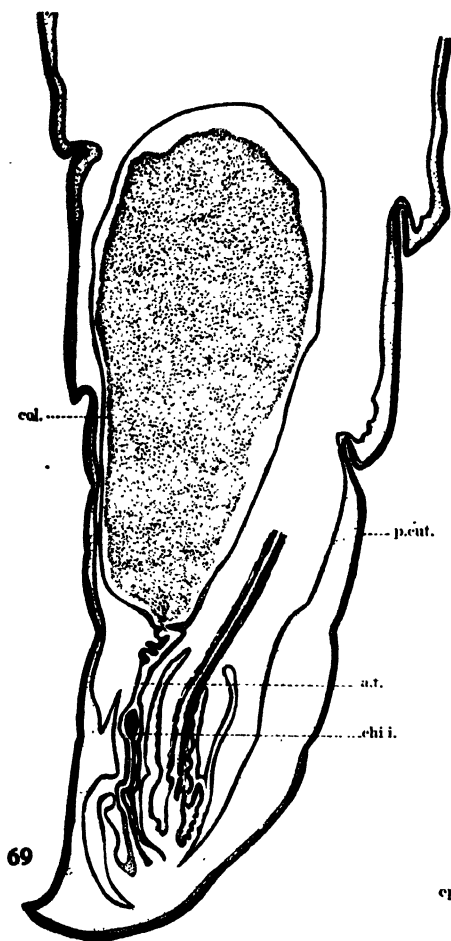




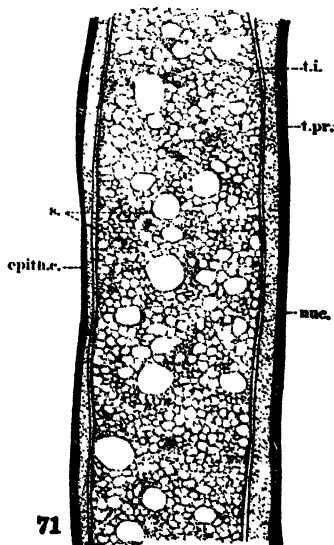
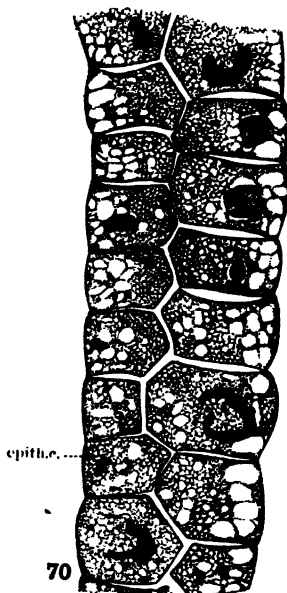


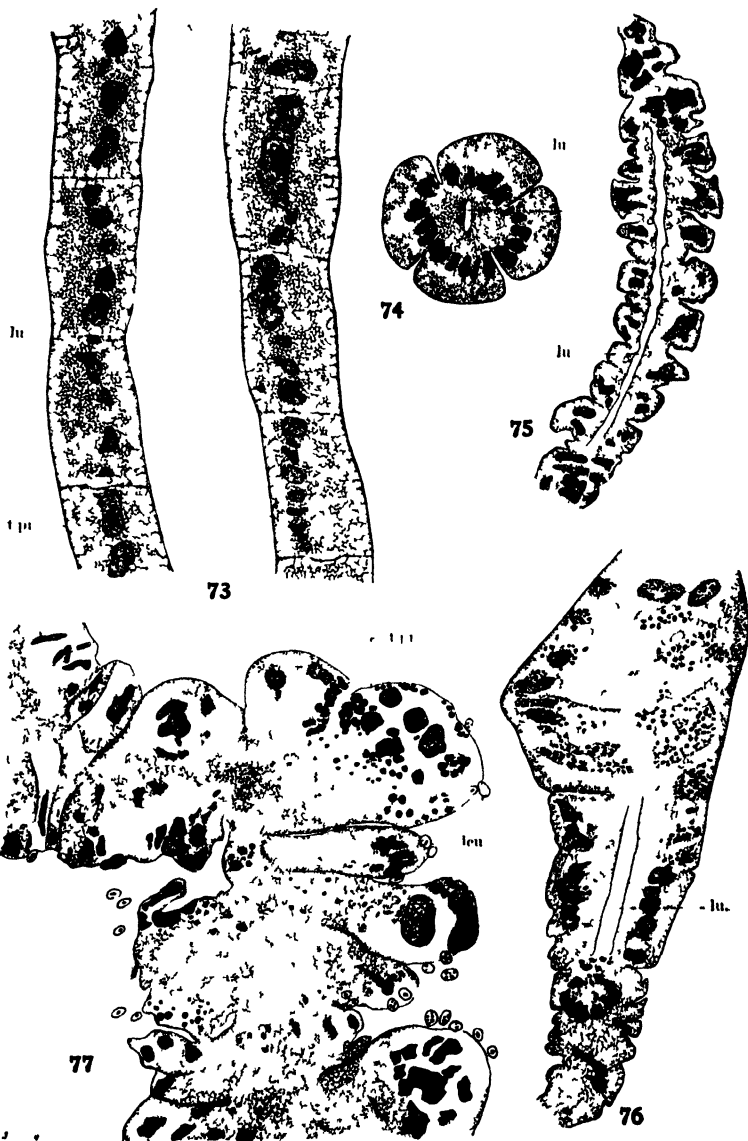


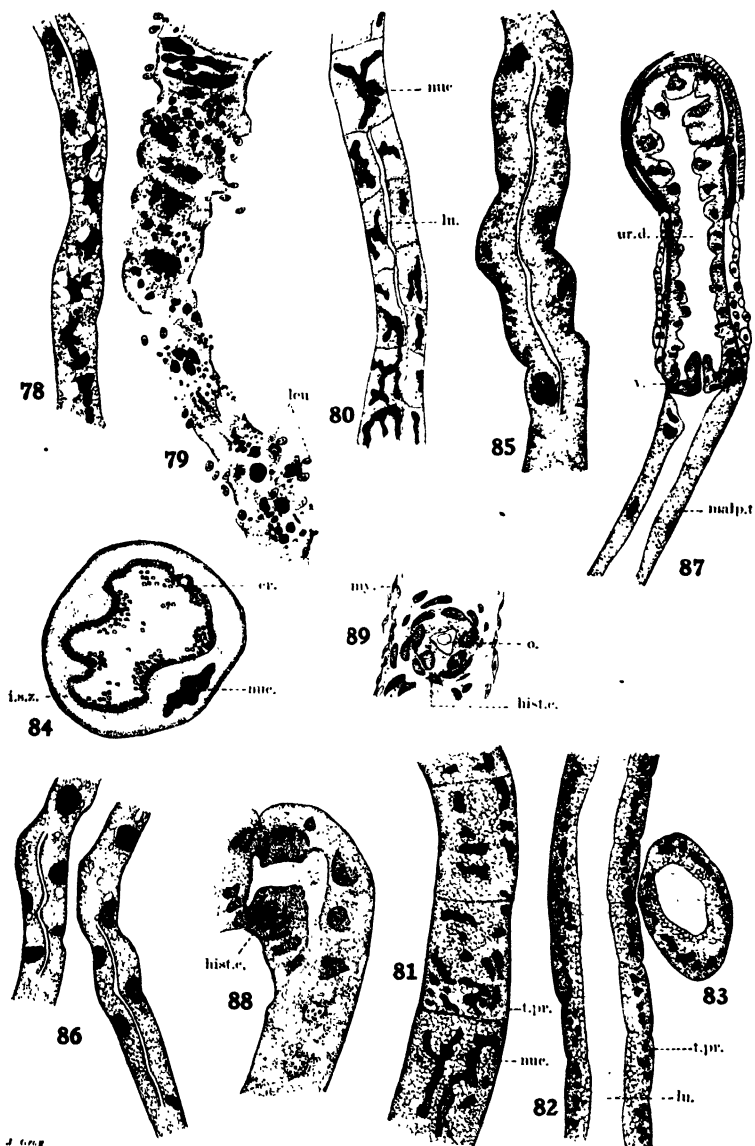




J. Gray







NOTES ON THE SAWFLY SUBFAMILY TENTHREDININÆ, WITH DESCRIPTIONS OF NEW FORMS.

(Hymenoptera, Tenthredinidæ).

HERBERT H. ROSS,
Illinois State Natural History Survey, Urbana, Ill.

This paper contains descriptions of new species and varieties, and notes on some other species, of the subfamily Tenthredininæ of MacGillivray (1916), or tribe Tenthredinini of Rohwer (1911). A great deal of the material examined was collected by Dr. C. H. Kennedy of Ohio State University and by Dr. E. H. Strickland of the University of Alberta, to whom the author wishes to express his sincere thanks for their generous assistance. The types erected in this paper are deposited in the collection of the Illinois State Natural History Survey unless otherwise stated.

Genus *Laurentia* O. Costa.

Since the appearance in 1918 of Mr. S. A. Rohwer's revision of the nearctic species of this genus, it has been found that two species recently described in the genus *Tenthredo* and an older name also described in *Tenthredo*, really belong in the genus *Laurentia*, and in placing these the following synonymic list of the nearctic species has been prepared.

Laurentia diluta (Cresson).

Tenthredo diluta Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 24, ♀.

Laurentia diluta Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1918, p. 159.

This rare species, recorded only from California, is known only from the female sex.

Laurentia rubens (Cresson).

Tenthredo rubens Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 24, ♂.

Tenthredo atravenus MacGillivray, Can. Ent., Vol. XXVII, No. 10, Oct., 1895, p. 283, ♂; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 262. *New synonymy.*

Laurentia rubens Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1918, p. 159, ♂, ♀.

Tenthredo racilia MacGillivray, Journ. N. Y. Ent. Soc., Vol. XXXI, No. 2, June, 1923, p. 112, ♂; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 263. *New synonymy.*

The opinions and surmises given by Rohwer (1918) regarding the sub-specific position of *L. edwardsii* (Cress.) and *L. aldrichii*

(MacG.) are fully adopted by the present writer. The yellow mark on the meso-episternum, which was the character used for separating both of these forms from *L. rubens* (Cress.), is subject to considerable variation, and specimens from Moscow, Idaho, with this spot almost obsolete were associated with males which were typical *rubens*. All the males examined have the meso-pleuræ entirely black. The species has been taken from various localities in California, Idaho, Nevada, Oregon, Washington, and British Columbia.

***Laurentia rubens* var. *ruficornia* (MacGillivray).**

Tenthredopsis ruficornia MacGillivray, Can. Ent., Vol. XXV, No. 10, Oct., 1893, p. 242, ♀; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 267.

Astochus fletcheri MacGillivray, Can. Ent., Vol. XLVI, No. 3, Mar., 1914, p. 108, ♀; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 237.

Kincaidta ruficornia MacGillivray, Can. Ent., Vol. XLVI, No. 4, Apr., 1914, p. 137.

Laurentia edwardsii var. *ruficornia* Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1918, p. 159.

Tenthredo refractaria MacGillivray, Journ. N. Y. Ent. Soc., Vol. XXXI, No. 2, June, 1923, p. 113, ♀; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 264. *New synonymy.*

This variety differs from the typical form in having a yellow spot on the meso-episternum, and from var. *edwardsii* (Cress.) in having the scutellum black. It has been recorded from Idaho, Oregon, Washington and British Columbia.

***Laurentia rubens* var. *edwardsii* (Cresson).**

Tenthredo edwardsii Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 24. ♀.

Laurentia edwardsii var. *edwardsii* Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7, Oct., 1918, p. 158.

Characterized by the yellow, or partly yellow, scutellum. Recorded from California, Nevada, Washington and British Columbia.

***Laurentia rubens* var. *aldrichi* (MacGillivray).**

Astochus aldrichi MacGillivray, Can. Ent., Vol. XLVI, No. 4, April, 1914, p. 137, ♀; Frison, Bull. Ill. Nat. Hist. Surv., Vol. XVI, Art. IV, Feb., 1927, p. 237.

Laurentia aldrichi Rohwer, Proc. Ent. Soc. Wash., Vol. 20, No. 7 Oct., 1927, p. 159.

The specimen described by MacGillivray, from Juliaetta, Idaho, is in almost all respects similar to var. *ruficornia* (MacG.), to which it runs in Rohwer's key (1918), but is smaller and has the antennæ entirely rufous, concolorous with the legs. It seems advisable to consider it a variety on the basis of this latter difference in color. Known only from the holotype.

Genus **Pachyprotasis** Hartig.**Pachyprotasis omega** Norton.

Pachyprotasis Omega Norton, Trans. Amer. Ent. Soc., Vol. I, 1867, p. 280, ♀, ♂.
Macrophya obnata MacGillivray, Univ. Ill. Bull., Vol. XX No. 50, Aug. 13, 1923,
p. 22, ♀. *New synonymy.*

Female specimens of *P. omega* Nort. differ from specimens from England determined by Mr. R. W. Benson as *P. rapæ* (L.) in having the apical half of the posterior femora solid black and the hind tibiæ entirely black. *P. rapæ* has, in the female, the black on the hind femora in anterior and posterior bands, with the narrow upper and lower edges usually light; the black usually extends nearer to the base than in *P. omega*; and the hind tibiæ have a light narrow streak on the ventral side. The males appear identical. It may be that *P. omega* is a darker form of *P. rapæ*, but the differences in the female have been observed to be constant in over thirty specimens from widely scattered points of North America, so that in view of the continental distribution it seems advisable to retain *omega* as a distinct species.

Kincaid has identified Escherich's species *Tenthredo nigri-fascia* as this species. Escherich's description, however, is vague as to the color of the legs and might possibly apply to some other similarly colored species, so that for the present I am considering it as of uncertain identity.

Specimens of *P. omega* have been examined from the following localities: 1 ♀, Straiton, B. C., May 11, 1926 (G. I. Noble); 1 ♂, Agassiz, B. C., April 26, 1927 (H. H. Ross); 1 ♂, Edmonton, Alta., July 26, 1912; 1 ♀, Edmonton, July 13, 1929 (E. H. Strickland); 6 ♂♂, 16 ♀♀, Gull Lake, Alta., June, 1929 (E. H. Strickland); 1 ♀, Aweme, Man., July 9, 1913 (N. Criddle); 1 ♂, 1 ♀, Montreal, P. Q., July 11, 1905; 1 ♂, 1 ♀, Juliaetta, Ida., May 3, 1901; 1 ♀, Black Mts., N. C., June 17; 1 ♀, Saranac Inn, N. Y., June 17, 1900.

Genus **Tenthredella** Rohwer.**Tenthredella glacialis** new species.

Female.—Length, 13.5 mm. Color mostly black. Head black, including antennæ, with the following parts creamy white: palpi, outer and upper faces of mandibles, labrum, clypeus, front below bases of antennæ except fronto-clypeal suture which is black, a spot

above the base of each antenna, a fairly wide line running the entire length of the inner margin of the eye and beyond it almost to the posterior margin of the head and another line running through the postgenae from the lower corner of the eye to a point almost midway between the upper corner of the eye and the posterior margin of the head. Thorax black with the following parts white or creamy white: anterior and lateral margins and lateral two-thirds of posterior margin of pronotum, tegulae, central area of mesoscutellum, narrow lines on lateral portions of posterior margin of metanotum, rarely a vertical spot on mesopleurae below tegulae, and a spot of variable size on metaepisternum. Abdomen black with a large spot on the lateral margins of basal plates, and the posterior angles of the ventral portion of the terga, white. Coxae, trochanters, posterior femora and posterior tarsi except apical segment, black: front and middle femora black with a white line on anterior side, narrow near base and widening towards apex; front and middle tibiae with posterior side black and anterior side white, hind tibiae somewhat the same but with the black completely encircling the apical fourth and the white completely, or almost completely, encircling the basal fourth: front tarsi whitish except an interrupted fuscous dorsal line, middle tarsi whitish with a black dorsal line, hind tarsi entirely black with the exception of the basal two-thirds of the last segment which is whitish. Wings hyaline, but with just a suggestion of a tawny infuscation, especially below stigma; base of stigma whitish, costal margin beyond stigma light brown, stigma and veins dark brownish black.

Head shining, only sparsely punctured; ridges and furrows only moderately pronounced: postocular area robust, not narrowed behind eye; antennae with third segment at most only a fourth longer than fourth, and with the last two segments subequal. Thorax with anterior lobe and scutellum dull with dense fine punctures, remaining lobes more sparsely punctured and shining; scutellum shallow, feebly to moderately strongly convex; post-tergite with moderate, separate punctures covering all but the rounded median ridge; tarsal claws deeply cleft, the rays strong and diverging, the inner one short and thicker at base.

Male.—Length, 11 mm. Color essentially as in female, but with the white coloration on the mesopleurae, legs and abdomen extremely variable, and usually much more extensive than in the female, as follows: front and middle legs, including coxae, with anterior aspect entirely white; posterior coxae usually with a few apical white dots; white angulate mark usually extending entirely across meso-episternum, sometimes only the anterior portion of the mark present; sterna of abdomen usually white. Structure as in female.

Holotype.—♀, Oakwood, Illinois, July 4, 1930 (H. H. Ross).

Allotype.—♂, same data as holotype.

Paratypes.—23 ♂♂, 21 ♀♀, including two mating pairs, Oakwood, Illinois, June 15 and 22 and July 4, 1930 (H. H. Ross). Collected in thick woods along the Salt Fork River.

The female of this species differs from *T. carolina* Rohwer in the white scutellum and the white on the venter of the abdomen. From *T. lobatus* (Norton) it differs in the white scutellum and in lacking the *V*-spot on the anterior lobe, in having a shorter postgenal white line, and in being slightly larger. The males of only a few species of this group are known, so that positive diagnostic characters can not be given for this sex. It is probable, however, that the white scutellum will be an important character for its separation.

***Tenthredella fisheri* Rohwer.**

Tenthredella fisheri Rohwer, Proc. U. S. Nat. Mus., Vol. 45, No. 1981, May 22, 1913, p. 276, ♀.

Male.—Length, 10 to 11 mm. Color, very similar to female, as follows: head and dorsum of thorax colored as in female; pectus and a wide angular mark on meso-episternum white; front legs white with a narrow or incomplete black line on posterior surface; middle legs white with a broader, complete black line on posterior surface; hind femora black with the narrow ventral edge white or whitish, hind tibiae black with an incomplete white ring on basal half or third; abdomen with venter white except hypopygium which is black, and with dorsum black except median dorsal yellowish white line, which is narrow on the basal plates, gradually widens until it is usually half the width of the abdomen on the fourth tergite, then becomes indistinct on the apical three terga. Wings and structure as in female.

Allotype.—♂, Oakwood, Illinois, June 22, 1930 (H. H. Ross).

Specimens examined: 17 ♂♂, 16 ♀♀, Oakwood, Ill., June 15 to July 4, 1930, collected in woods along the Salt Fork River (H. H. Ross).

The male of this species will probably be difficult to separate from the males of *T. lobatus*, *maculosa* and especially *angulifer*, but from all the males known from this group, it may be separated by the median abdominal dorsal line.

***Tenthredella maculosa* Smulyan.**

Tenthredella lobata subspecies *maculosa* Smulyan, Can. Ent., Vol. XLVII, No. 9, Oct., 1915, p. 324, ♂, ♀.

The constancy of the characters demarking this form from *T. lobata* (Nort.), and the constancy of small color differences between large series of other species to which this is allied, give good grounds for considering *maculosa* a distinct species and not a subspecies of *lobata*. Specimens bearing the follow-

ing data have been examined: 1 ♂, 2 ♀ ♀, Algonquin, Ill., June 7, 1895 (W. Nason); 1 ♀, Oakwood, Ill., June 22, 1930 (H. H. Ross); 1 ♀, Battle Creek, Mich., (J. M. Aldrich); 4 ♀ ♀, Ithaca, N. Y., June and July, 1918; 1 ♂, 1 ♀, Put-in-Bay, Ohio, May, 1926 (C. H. Kennedy); 1 ♂, Blue Mds., Wis., June 15, 1918 (S. B. Fracker).

The three preceding species belong to a group of six nearctic species in which the compound eyes are almost surrounded by areas or lines of white or yellowish and the dorsum of the abdomen is entirely black, except for a median longitudinal pale line in *T. fisheri* Roh. *Tenthredo ventralis* Say undoubtedly belongs in this group, but owing to its meager description has never been recognized, and in addition the type has been lost. The following key will be of assistance in separating the females of the nearctic species of this group. The males of many are as yet undescribed; hence, cannot be keyed.

1. Dorsum of abdomen with a median, longitudinal white or greenish line..... *fisheri* Rohwer 2
Dorsum of abdomen entirely black..... 2
2. Scutellum white; V-spot absent..... *glacialis* Ross 3
Scutellum black; V-spot present or absent..... 3
3. Pectus whitish or yellowish; mesopleurae with a broad pale line, *angulifer* (Norton) 4
Pectus black; mesopleurae black or with an interrupted pale line..... 4
4. Posterior angles of lateral lobes white, thus making an angular white dot on each side of scutellum; mesonotum with several longitudinal white lines..... *maculosa* Smulyan 5
Posterior angles of lateral lobes black; mesonotum with no white marks except sometimes a V-spot..... 5
5. Anterior lobe of mesonotum with white V-spot; apices of abdominal sterna white..... *lobata* (Norton) 5
Anterior lobe and abdominal sterna black..... *carolina* Rohwer 5

***Tenthredella fraternalis* new species.**

Female.—Length, 10 to 11 mm. Color, except legs, black with the following parts white or yellowish white: palpi, mandibles except tips, clypeus, labrum, lower portion of genæ, minute spot on inner posterior margin of eyes, posterior angles of pronotum broadly, tegulae, minute spot on ventral corner of pronotum, large spot on meta-episternum, and postero-lateral angles of basal plates. Legs yellowish rufous, except extreme bases of coxae which have inconspicuous black marks; front legs more yellowish than rufous. Wings almost hyaline, faintly infusate with brownish; costa beyond stigma and basad of it, reddish brown; costa immediately basad of stigma, stigma and veins, dark brown.

Inner margin of antennal sockets considerably upraised, more so than in *T. leucostoma* (Kby.); dorsal portion of head smooth and shining; minutely and sparsely punctured; ridges and furrows well marked;

anterior and lateral lobes of mesonotum more or less opaque with small, close punctures, post-tergite with quite large, distinct punctures except for the median ridge which is carinate and shining; tarsal claws cleft, the inner ray slightly the shorter.

Holotype.—♀, Waterton, Alberta, July 12, 1923 (E. H. Strickland). Deposited in the Canadian National Museum.

Paratype.—1 ♀, Field, British Columbia, July 26, 1906. In the author's collection.

This species differs from *T. leucostoma* (Kby.) in having the hind tibiae and tarsi rufous, and the cheeks yellow; from *T. mellipes* (Roh.), to which it is probably most closely related, in having the cheeks and collar yellow, and from *T. ruficollis* (Hartrn.) in having the coxae rufous and the cheeks yellow.

***Tenthredella rufopedibus* (Norton).**

Tenthredo rufopedibus Norton, Proc. Ent. Soc. Philadelphia, Vol. III, 1864, p. 15, ♂.
Tenthredo rubricosa MacGillivray, Univ. Ill. Bull., Vol. XX, No. 50, Aug. 13, 1923, p. 35, ♂. *New synonymy*.

Female.—Length, 12 mm. Color, very similar to light forms of *T. leucostoma* (Kby.). Body mostly black, with the following parts creamy white: mandibles except tip, labrum, clypeus, a small spot on cheeks at base of eyes, an obscure spot on upper inner margin of eyes, posterior margin of pronotum, tegulae and meta-episternum, sometimes a horizontal mark on posterior portion of meso-episternum just above pectus, and rarely an obscure vertical mark just below tegulae. Pectus either black, or entirely rufous, or black with rufous bars. Abdomen black with a variable amount of the venter at the base creamy rufous or brownish rufous. Legs yellowish rufous with apical half or two-thirds of hind tibiae and all hind tarsi black.

Allotype.—♀, Cedar Bog, Urbana, Ohio, June 9, 1929 (C. H. Kennedy).

The following specimens of this species have been examined: 23 ♂♂ and ♀♀, same data as allotype; 4 ♂♂, 3 ♀♀, Algonquin, Ill., (Nasbn); 2 ♀♀, Northern Illinois; 1 ♂, Orono, Me., June 14, 1913. The rufous on the dorsum of the abdomen of the male varies considerably, from having the first three segments beyond the basal plates entirely rufous, to having them rufous at the base with an apical black band. The type of *T. rubricosa* is from Algonquin, Ill., and is a specimen with the first three terga rufous. There is a possibility that this is a southern color form of *T. leucostoma* (Kby.).

***Tenthredella tricolor* (Norton).**

Allantus tricolor Norton, Boston Jour. Nat. Hist., Vol. VII, 1860, p. 247, ♀.

Tenthredo cressonii Kirby, List Hymen. British Mus., Vol. I, 1882, p. 315, ♀.

New synonymy.

Tenthredella rohveri Smulyan, Can. Ent., Vol. XLVII. No. 10, Oct., 1915, p. 323.

N. n. for *tricolor* Nort.

Tenthredella tricolor Smulyan, Proc. Boston Soc. Nat. Hist., Vol. 36, No. 6, Jan., 1923, p. 441, ♀.

A large series of specimens from various localities in central and northern Canada shows this species to be one of the most variable in the genus. The abdomen varies from an almost entirely rufous condition to being entirely black; similarly the amount of rufous on the legs is extremely variable. Kirby's species *cressonii* is apparently the most rufous form described, having very little black at the base of the abdomen. It might be considered by some as a variety of *tricolor*. Norton's original description is of the form with the two basal segments entirely black, which is the commonest color pattern encountered. A continuous series of variations has been studied from this typical variety to the entirely black form, described by Norton as *Tenthredo concessus*. The male of this species, heretofore undescribed, has been definitely associated with the female.

Male.—Length, 9 mm. Structure similar to that of female. Color: head black with clypeus, labrum, outer lateral faces of mandibles, apical segments of palpi, and sometimes a spot variable in size on the postgenæ adjacent to the eye, chalky white; thorax, excluding legs and wings, entirely black, except usually a spot on the meta-episternum which is yellowish white. Abdomen bright rufous, with basal plates, more or less of dorsum of first and last segments, hypopygium and claspers, black. Legs mostly rufous and black; coxæ black, except anterior and sometimes lateral chalky spots on the front coxæ and an indistinct rufous area on the lateral aspect of the hind coxæ; trochanters black; femora with posterior side black, front femora with anterior side yellowish and middle and hind femora with anterior side rufous; front and middle tibiæ and tarsi rufous, with a more or less distinct black line above; hind tibiæ either entirely black or black with basal third reddish black; hind tarsi black with apical segment rufous. Wings with costa, subcosta and stigma blackish brown; veins dark brown; membrane hyaline, very slightly tawny infusate especially below stigma. Two specimens believed to belong to this species have the hind femora and most of the middle ones entirely black.

Allotype.—♂, Gull Lake, Alberta, June 18, 1929 (E. H. Strickland).

The female of typical *tricolor* and its slighter variations is easily separated from species with a rufous-banded abdomen in lacking yellow marks on the orbits, collar, tegulæ and dorsum of the thorax, and in having a rufous area on the genæ and *rufous* instead of *yellow* combined with black on the legs.

The following specimens of the typical form, or variations so slight that they may be considered within the typical sense, have been examined: Alberta, 8 ♂♂, 10 ♀♀, Edmonton and Gull Lake, June 8 to July 1, 1929 (E. H. Strickland); 2 ♀♀, Edmonton, June 5 and 6, 1924 (O. Bryant); Saskatchewan, 1 ♀, Fort a la Corne, July 17, 1925 (Kenneth M. King); Manitoba, 1 ♂, Aweme, June 29; 3 ♀♀, Aweme, June 17; 1 ♀, Birtle, June 21; 1 ♀, Treesbank, July 6, all 1926 (R. D. Bird); Montana, 1 ♀, Gallatin Mts., July 7, 1914; 1 ♀, Bozeman, June 30, 1916; South Dakota, 3 ♀♀, Spearfish, July 16 and 26, 1923 and 1924, (H. C. Severin).

***Tenthredella tricolor* var. *concessus* (Norton).**

Tenthredo concessus Norton, Trans. Amer. Ent. Soc., Vol. II, 1869, p. 238, ♀.
Tenthredo uniformis Kirby, List Hymen. British Mus., Vol. I, 1882, p. 317, ♀.
New synonymy.

This variety, in which the body is almost entirely black, is most easily confused with *T. melanosoma* (Harrington), but is easily separated from it and its close allies by having *rufous* instead of *yellow* on the anterior face of the front legs. The amount of rufous on these parts varies considerably, Kirby's description of *uniformis* representing the most extensive development of rufous and Norton's description of *concessus* the least extensive. Specimens showing the following distribution have been studied: Maine, 1 ♀, Orono, June 23, 1913; Michigan, 1 ♀, Cheboygan County, Douglas Lake, June 25, 1925 (C. F. Byers); Alberta, 1 ♀, Edmonton, July 1, 1912 and 3 ♀♀, Gull Lake, June 20 to 28, 1929 (E. H. Strickland); and Manitoba, 2 ♀♀, June 29 and July 10, 1926 (R. D. Bird).

***Tenthredella tricolor* var. *savanna* new variety.**

Female.—Similar in size and structure to the typical *tricolor*. In color transitional between the typical form, which has the abdomen rufous with the two basal segments more or less black, and *tricolor* var. *concessus* which has the abdomen entirely black. Body black with the following parts yellow: mandibles except tip, labrum and clypeus, a minute spot on inner, upper margin of eye, cenchri, sometimes a spot on

meta-episternum and a small spot on ventro-lateral margin of basal plates; with the following parts rufous: lower portion of genæ and first antennal segment in most cases; front legs beyond coxæ except more or less of posterior aspect of femora, middle tibiæ and tarsi, apical half to entire anterior aspect and sometimes an apical spot on posterior aspect of middle femora, more or less of base of posterior tibiæ, and posterior tarsal segments except sometimes at apex; and third, or third and fourth or third, fourth and part of second, abdominal segments.

Holotype.—♀, Gull Lake, Alberta, June 14, 1929 (E. H. Strickland).

Paratypes.—7 ♀♀, Gull Lake, Alta., June 8 to 28, 1929 (E. H. Strickland); 1 ♀, Edmonton, Alta., June 2, 1924 (O. Bryant); and 1 ♀, Spearfish, S. D., July 26, 1924 (H. C. Severin). Deposited with the holotype and in the Canadian National Museum, the University of Alberta, and the South Dakota State College.

***Tenthredella stricklandi* new species.**

Female.—Length, 9 to 10 mm. General color, greenish or yellowish white with black maculations as follows: antennæ except ventral half beyond two-thirds the length of first segment, and lateral and part of mesal surfaces of scape, which are greenish white; a spot surrounding ocelli, extending between raised margins of antennal sockets, including anterior half of postocellar area and extending laterally one-half or less the distance between the antennal furrows and the eyes; vertical furrows, a spot on postero-lateral margin of eye near apex, a small spot opposite eyes on the posterior margin of head, and the entire posterior aspect of the head; greater part of mesonotum except broad, complete V-spot on anterior lobe, a pair of arrow-shaped marks on lateral lobes, scutellum entirely, post-tergite and more or less of sutures of posterior region, which are greenish white; lateral lobes of metanotum; entire pectus, a broad line on the ventral margin of the meso-epimeron and sutures of meta-pleuræ; and the sternites of the abdomen and the sheath. Legs, including coxæ, greenish white with a moderate black line down the posterior side of the femora, tibiæ and tarsi, more or less evanescent at the base of femora and usually thin and interrupted on all the tibiæ. Wings hyaline: costa, stigma and base of anal veins green or greenish white, remainder of veins shining black or brownish black. In older, pinned specimens the dorsum of the abdomen, green in life, discolors, and becomes a pale brownish white.

Mesal margins of antennal sockets strongly produced and raised; fourth antennal segment only two-thirds length of third; dorsum of head polished, with few, minute punctures, lateral lobes with sparser punctures; scutellum only feebly convex, shining, scarcely punctate; post-tergite flat with a slight median carina, with separate, fairly large punctures around the posterior margins; tarsal claws cleft, the inner ray slightly the shorter.

Male.—Length, 8 to 9 mm. Color, greenish or yellowish white, with black markings essentially as in female, with the following exceptions: scape, pectus and entire abdomen greenish white; black markings on head behind eyes absent; black line on legs slightly stronger and wider. Structure as in female.

Holotype.—♀, Waterton, Alberta, July 13, 1923 (E. H. Strickland).

Allotype.—♂, same data, but July 12.

Paratypes.—1 ♂, 6 ♀ ♀, same data as holotype and allotype; 3 ♂ ♂, 7 ♀ ♀, Gull Lake, Alta., June 14 to 28, 1929 (E. H. Strickland); 1 ♀, Edmonton, Alta., June 30, 1923 (E. H. Strickland); 1 ♀, Moscow, Idaho, June 18, 1895 (J. M. Aldrich); 2 ♀ ♀, Ground Hog Basin, Big Bend Country, Selkirk Mts., B. C., July 24, 1905 (J. C. Bradley). Deposited with the holotype, and in the collections of the Canadian National Museum, the University of Alberta, the University of Illinois, and the author.

This species is most closely related to *T. rhammisia* (MacG.), but is smaller and differs in the female in having the pectus and venter of the abdomen black, and in the male in having the flagellum of the antennæ greenish beneath. In color both *T. stricklandi* and *T. rhammisia* resemble several species of *Rhogogaster*, for which they have often been mistaken in collections.

***Tenthredella rhammisia* (MacGillivray).**

Tenthredo rhammisia MacGillivray, Univ. Ill. Bull., Vol. XX, No. 50, Aug. 13, 1923, p. 33, ♀.

Male.—Length, 10 to 11 mm. Color in life virid light green with black markings. In mounted specimens the green changes to yellowish or greenish white. Color distribution and markings exactly as in female. Antennæ in both sexes with basal segment entirely yellowish or mostly black with yellowish lines or spots; flagellum normally entirely black, sometimes suffused with fuscous on ventral side towards tip. Black line down posterior aspect of legs slightly stronger in male. Structure similar in both sexes.

Allotype.—♂, Vancouver, British Columbia, July 1, 1929 (H. H. Ross).

Specimens of this species have been examined from the following localities: ♀ (holotype), Sea Side, Ore., August 15, 1914 (L. G. Gentner); 1 ♂, Alsea, June 4, 1922 (A. L. Lovett) and 2 ♀ ♀, Corvallis, June, Ore.; 1 ♀, Olympia, May 27, 1894, and 1 ♀, Mt. Steel, Jefferson County, July 17, 1919 (F. M.

Gaige), Wash., 2 ♂♂, same data as allotype, and 1 ♂, Agassiz, May 18, 1926 (H. H. Ross), B. C.

This species is closely related to *T. stricklandi* Ross, under which the differentiating characters are given. It differs markedly from that species in having the two sexes concolorous. It has the mesal margins of the antennal sockets moderately raised, and the scutellum and post-tergite as in *stricklandi*.

***Tenthredella perplexus* (MacGillivray).**

Tenthredo perplexus MacGillivray, Jour. N. Y. Ent. Soc., Vol. V, No. 3, Sept., 1897, p. 106, ♀.

Tenthredo commata Konow, Zeits. Hymen. Dipt., Vol. 8, Heft 1, Jan. 1, 1908, p. 90, ♀. *New synonymy*.

The description of Konow's specimen from Alaska agrees in every particular with MacGillivray's type specimen from Washington and with other specimens from Oregon.

Genus *Macrophya* Dahlbom.

***Macrophya fumator* Norton.**

Macrophya fumator Norton, Trans. Amer. Ent. Soc., Vol. I, 1867, p. 279, ♀.

Macrophya jugosa Cresson, *ibid.*, Vol. VIII, 1880, p. 18, ♂. *New synonymy*.

Macrophya bicolorata Cresson, *ibid.*, ♀. *New synonymy*.

Synairema pacifica Provancher, Addit. Vol. II, Faun. Ent., Hymen., 1889, p. 15, ♀. *New synonymy*.

Perineura kincaidia MacGillivray, Can. Ent., Vol. XXVII, No. 1, Jan., 1895, p. 7, ♀. *New synonymy*.

Macrophya obrussa MacGillivray, Univ. Ill. Bull., Vol. 20, No. 50, Aug. 13, 1923, p. 22, ♂. *New synonymy*.

The holotype of *P. kincaidia* MacGillivray is a specimen identical in every respect with the typical form of *fumator*. Specimens identified by Dr. MacGillivray as *S. pacifica* Provancher are typical of the form *bicolorata* Cresson, lacking the white spot on the hind tibiae. The male of this species has the abdomen always black, not varying as in the female. In the male, also, the white spot on the apices of the hind tibiae varies considerably in size, but no specimens have been examined in which it was entirely absent. On the humid belt of the Pacific Coast a melanic form of the female appears in which the abdomen is entirely black, viz. var. *maura* Cresson. The typical form occurs in the same locality but no intergrades between the two have been seen. Specimens from this region have the white spot on the hind tibiae very large, often half the length of the tibiae. In more arid regions of higher altitudes, such as Idaho and western Colorado, only the females with a

rufous abdomen are taken, and in these the white spot on the hind tibiae is extremely variable, being found on different specimens in every state between and including being entirely absent to being a third or a half the length of the tibiae. The form in which the spot is absent was given the name *bicolorata* by Cresson, but since both this and the typical form may be taken in the same locality it does not seem advisable to the author to consider such a slight and variable difference in color under a separate varietal name.

The following specimens of this species have been examined: British Columbia, 1 ♀, Rock Cr., June 5, 1926 (P. N. Vroom); 1 ♀, Agassiz, May 29, 1927 (L. Black); 2 ♂♂, 1 ♀, Vernon, May and June (Buckell and Cutler); California, 1 ♀, Woodside, April 25, 1906 (J. M. Aldrich); 2 ♀♀, Berkeley, May 5, 1915 (M. C. VanDuzee); 1 ♂, Portola, June 5, 1915 (M. C. VanDuzee); Colorado, 1 ♀, "Col."; 1 ♀, Clear Cr., June 27, 1906 (Osler); Idaho, many ♂♂, ♀♀, Juliaetta, Bellevue, Lake Waha, Moscow and Reuben, May and June; Oregon, ♂♂, ♀♀, Corvallis, May and June (H. A. Scullen); Washington, ♂♂, ♀♀, Olympia. May and June (Trevor Kincaid); 1 ♀, Friday Harbor, May 30, 1906 (J. M. Aldrich).

***Macrophya fumator* var. *maura* Cresson.**

Macrophya maura Cresson Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 18, ♀.

This, as explained above, is a melanic variety of the female, the male being black in all forms of the species. The same climatic factors which apparently cause the abdomen to be black, seem at the same time to produce a very large apical white spot on the hind tibiae, it being usually half the length of the tibiae. The following specimens have been examined: 2 ♀♀, Agassiz, B. C., May 29, 1927 (L. Black) and May 16, 1927 (H. H. Ross); 3 ♀♀, Corvallis, Ore., 1900; 2 ♀♀, Corvallis, Ore., June 1, 1927 (H. A. Scullen); 1 ♀, Olympia, Wash., (Trevor Kincaid).

***Macrophya subviolacea* Cresson.**

? *Macrophya pumilus* Norton, Trans. Amer. Ent. Soc., Vol. II, 1867, p. 272, ♂.
Macrophya subviolacea Cresson, *ibid*, Vol. VIII, 1880, p. 18, ♀.

A series of eight females of this species in the A. D. MacGillivray Collection, bearing the data "Berkeley, Calif., May 15, 1915 (M. C. VanDuzee)," have been studied. In this species

the rugose front below the ocelli, the large, well-separated punctures on the scutellum, and the highly polished surfaces of the mesonotum are very typical of *M. fumator* Nort. The color of the wings and the body is exactly as in *M. fumator* var. *maura* Cress., with the exception of the hind tibiae which are entirely black without a trace of the apical white spot. In *M. fumator* var. *maura* there is a marked tendency for this spot to increase rather than decrease in size, and for this reason *subviolacea* is considered a distinct species closely related to *fumator*.

I have not seen any specimens of Norton's species *pumilus*, but his description of it agrees well with *subviolacea*, the differences in color of legs, wings, labrum and clypeus being the same as the differences between the male and female of *fumator*. If the study of a large series of specimens indicates that this surmise is correct, Cresson's name *subviolacea* will have to be considered a synonym.

***Macrophya oregona* Cresson.**

Macrophya oregona Cresson, Trans. Amer. Ent. Soc., Vol. VIII, 1880, p. 19, ♀.

Macrophya obaerata MacGillivray, Univ. Ill. Bull., Vol. 20, No. 50, Aug. 13, 1923, p. 21, ♀. *New synonymy.*

The specimen described by Dr. MacGillivray is structurally identical with typical *M. oregona* Cresson, but differs slightly in color in having a small *V*-spot on the anterior lobe of the mesonotum and a spot on the dorso-apical portion of the hind femora, white. The four specimens at hand of this species studied by the author show four sequential steps from the condition in which the hind femora are entirely black to that in which they are almost entirely ringed with white at the apex, and one has the *V*-spot, absent in two, even larger than has the type of *obaerata*. Since this variation occurs in so few specimens it is natural to suppose that the species is consistently variable in these characters, and since, furthermore, the variation occurs in specimens from relatively close geographical points, it seems scarcely advisable to retain *obaerata* as a variety. The data associated with the typical specimens studied are as follows: 1 ♀, Olympia, Wash. (Trevor Kincaid); 1 ♀, Corvallis, Ore. (Fitch); 1 ♀, Agassiz, B. C., July 6, 1927 (H. H. Ross); 1 ♀, Vancouver, B. C., June 26, 1929 (H. H. Ross).

No males corresponding to this phase have been seen, but three have been taken which are intermediate between this and the following darker variety. These have the scutellum partly white and one has one segment of one antenna almost entirely white. They were taken with the female from Vancouver. It may be that the males never do have as rich a white ornamentation as the females.

***Macrophya oregona* var. *dukiae* new variety.**

Male.—Length, 7 to 8 mm. Color of body entirely black except the following parts which are white: labrum, apical half or two-thirds of clypeus, lateral aspect of mandibles, and most of the ventral aspect of the abdomen. Antennæ entirely black. Front and middle coxæ with basal third black, apices white, hind coxæ black with mesal half of ventral aspect and an elongate spot near base along the dorso-lateral angle, white; trochanters white; front and middle femora, tibiæ and tarsi with anterior face white, posterior face black, tarsi sometimes with a pale, ringed appearance; hind femora black with more or less of the ventral edge white towards base; hind tibiæ black with an elongate-oval white spot varying from one-sixth to one-quarter the length of the tibiæ, near the apex on the dorsal side; hind tarsi black, the apical two segments shading to light brown. Wings hyaline at base, apical half very lightly brown infuscate.

Structure similar to the typical *oregona* female.

Female.—Size and structure as in the typical form. Differs in color in having the antennæ and scutellum *entirely black*. The V-spot and the hind femora are also entirely black, and the middle femora have only a little white at each end.

Holotype.—♂, Vancouver, British Columbia, July 1, 1929 (H. H. Ross).

Allotype.—♀, same data as holotype.

Paratypes.—7 ♂♂, same data as holotype, and 1 ♀, Muir Woods, Marin County, Calif., May 19, 1915 (M. C. VanDuzee).

Due to its black coloring, this variety is most likely to be confused with *M. fumator* var. *maura* Cress. and *M. subviolacea* Cress., but may be separated from them by the closely punctured and rough scutellum and the white lateral spot on the hind coxæ.

This variety is interesting in that it is the first case on record of a nearctic species of *Macrophya* in which the antennæ may vary in color from almost entirely white to entirely black.

***Macrophya fascialis* Norton.**

Macrophya fascialis Norton, Trans. Amer. Ent. Soc., Vol. II, 1889, p. 276, ♀.

A large series of the typical form of this species has been collected at Oakwood, Ill., June 15 to July 4, 1930 (H. H. Ross). The male is similar in color to the female.

***Macrophya fascialis* var. *puella* new variety.**

Female.—Identical in size and structure with typical *fascialis*. Differs in color as follows: cheeks, orbits, meso- and metapleuræ and basal plates entirely black instead of white, some specimens with minute white spots on these parts, but never suggestive of the extent to which they are present in the typical form. Abdomen, as in the latter, either entirely rufous beyond the first segment or with the apical two or three segments blackish or black. Color of legs essentially as in typical *fascialis*.

Male.—Similar to female, but with the more or less sanguineous red of the female replaced by a lighter orange-red. *V*-spot on anterior lobe almost absent.

Holotype.—♀, Douglas Lake, Michigan, July, 1929 (C. H. Kennedy).

Allotype.—♂, same data.

Paratypes.—13 ♀ ♀, same data.

This variety is very similar in structure and color to *M. varius* (Nort.), from which it is easily distinguished by the color of the hind femora as given in the key which follows the treatment of these species.

***Macrophya varius* (Norton).**

Allantus varius Norton, Boston Jour. Nat. Hist., Vol. VII, 1860, p. 240, ♀.

I have not yet seen typical specimens of this species, but in his descriptions of it, Norton notes, among others, the following color characters: scutellum, post-tergite and metascutellum white; legs yellowish rufous, no mention being made of black on the coxæ; basal plates and abdomen rufous.

Certain color phases of what appear to be this species have been studied and due to the possibility that more than one species might be involved, it has seemed advisable to give varietal names to the more distinct of these. Males of this species have the basal two segments of the antennæ either yellowish rufous or black without correlation with other color

characters. Although only relatively few records are available, there seems to be indicated a geographical segregation of these varieties, but until more material is examined it will be unsound to make any general statements in this respect. The relations of the various varietal forms may be seen in the accompanying key.

***Macrophya varius* var. *festana* new variety.**

Female.—Similar to the description of *varius*, but differing in the following color characters: only the basal segment of antennæ rufous; V-spot and scutellum white, but post-tergite and metascutellum rufous or rufous with anterior margin black; abdomen rufous with the four apical terga and sawguides *black*. Hind coxæ, metapleuræ, basal plates and base of abdomen rufous, slightly lined with black at base; femora rufous; front and middle tibiæ with posterior aspect black; hind tibiæ rufous, apex blackish and with a dorsal white spot; hind coxæ with lateral white spot; hind basitarsus black with a white ring or dot at apex, remaining hind tarsi white with black ring at apex.

Holotype.—♀, Algonquin, Illinois (Wm. Nason).

Paratypes.—1 ♀, Northern Illinois (Coll'n of G. C. Davis); 1 ♀, Douglas Lake, Mich., July (C. H. Kennedy); 1 ♀, Aweme, Man., July 18, 1913 (E. Criddle).

This variety possesses the peculiar combination of rufous coxæ, basal plates, etc., with black hind basitarsi and apical segments of the abdomen.

***Macrophya varius* var. *eurythmia* Norton.**

Macrophya eurythmia Norton, Trans. Amer. Ent. Soc., Vol. I, 1867, p. 276, ♀, ♂.

Macrophya nidonea MacGillivray, Can. Ent., Vol. XXVII, No. 3, Mar., 1895, p. 77, ♂. *New synonymy*.

The following specimens have been studied: 1 ♀, Edmonton, Alta., July 9, 1929 (E. H. Strickland); 4 ♀♀, Gull Lake, Alta., June 8 to 26, 1929 (E. H. Strickland); 1 ♀, Aweme, Man., June 24, 1912 (E. Criddle); 1 ♀, Aweme, Man., July 8, 1913 (N. Criddle); 1 ♂, 1 ♀, Montreal, P. Q., June 14 to 19, 1925 (J. W. Buckle); 1 ♂, 3 ♀♀, Orono, Me., July 7 to 22, 1913; 1 ♀, Mt. Washington, N. H.; 1 ♂, 1 ♀, Adirondack Mts., Axton, N. Y., June 12-22, 1901 (A. D. MacGillivray); 1 ♂, Karner, N. Y., June 5, 1906; 1 ♂, Nassau, N. Y., May 30, 1908. The female specimens from Maine, New York and Quebec differ in having the abdomen beyond the second segment

entirely chestnut in color, but in all other respects agree with Norton's description of *eurythmia*, and so I am considering them the extreme light form of the variety. The specimens from Alberta have the bases of the antennæ entirely black, and are midway between the typical form of the variety and var. *nordicola*. *M. nidonea* MacG. is undoubtedly a male of *varius* and agrees with the color characteristics of this variety.

Macrophya varius var. *nordicola* new variety.

Female.—Similar in size and structure to typical *varius*. Differs in color in being almost entirely black. Body, including abdomen, black, with the following parts white: base of mandibles, clypeus, labrum, two spots on posterior margin of head behind ocelli, apical four antennal segments except extreme tip of ninth, posterior margin of collar, V-spot, scutellum, spot at apex of post-tergite metascutellum, apical margins of abdominal sternites and postero-mesal margins of ventral portion of tergites. Coxæ black with apices and lateral and mesal margins white; posterior pair with a large lateral white spot; trochanters white; remainder of front and middle legs with anterior aspect white and yellowish rufous, posterior aspect black or blackish rufous; posterior femora with basal third or fourth whitish, extreme apex ringed with black, remainder deep rufous, in one specimen with the dorsal half, both anterior and posterior, black, shading ventrally to a blackish rufous; hind tibiae black with middle half rufescent; hind tarsi all with a narrow apical black ring, and with basal half of basitarsus black, otherwise white. Abdominal tergum with a faint suggestion of fuscous on some parts of the meson.

Male.—Similar to female, but with the second and third tergites with the mesal central portion blackish fuscous, and with more white and less black on the front and middle legs.

Holotype.—♀, Gull Lake, Alberta, June 24, 1929 (E. H. Strickland).

Allotype.—♂, same data as holotype. Deposited in the Canadian National Museum.

Paratypes.—1 ♀ and 1 ♂, same locality, collector and year, June 20 and 18. In the collections of the University of Alberta and the author.

This variety is a step beyond *varius* var. *eurythmia* in the replacing of red by black, and is apt to be confused with *trisyllaba* var. *sinannula*, but is at once separated from that form by the rufous color of the legs and the large amount of white on the anterior aspect of the front and middle legs.

Macrophya trisyllabus (Norton).

Allantus trisyllabus Norton, Boston Jour. Nat. Hist., Vol. VII, 1860, p. 238, ♀.

Macrophya trisyllabus Norton, Trans. Amer. Ent. Soc., Vol. I, 1867, p. 274, ♂, ♀.

A large series of specimens shows that this species varies considerably, especially in the female, in the following color characters: the transverse white lines on the apical margins of the tergites, the distinctness of the *V*-spot on the anterior lobe of the mesonotum, the amount of white on the abdominal sterna, and the amount of white on the ventral margin of the hind femora. The typical form has all the markings well developed. In more southern localities these different markings vary in development more or less independently of each other, so that no satisfactory grouping can be made using any single one as a basis. The transverse white markings on the apical margin of the tergites when strongly developed are enlarged on the meson to form a series of triangular marks with the apices pointing basad; when more weakly developed the white first disappears on each side of this spot and the spot itself may be reduced to two small transverse spots, one on each side of the meson.

This species is most closely related to *M. zonalis* Norton, and may be confused with it, but in *zonalis* the white on the apices of the abdominal terga forms only a narrow line, not enlarged on the meson, but instead reduced or interrupted. The color of the hind coxæ can not be used to separate these two species, because although *zonalis* usually has the ventral face of the hind coxæ white and *trisyllabus* usually has it black, rare cases have been observed in which the opposite was the case. *Trisyllabus*, however, has never been observed with any trace of white on the mesopleuræ, while *zonalis* has always a white mark on the angle of the meso-episternum immediately beneath the tegulæ, and usually a large white spot or area below this.

About 150 specimens of the typical, or near typical, form of *trisyllabus* have been examined, representing the following distribution: Illinois, Algonquin, Savanna and Oakwood, June and July; Massachusetts, Chicopee, July 27, 1881, and Wellesley; Michigan, Douglas Lake, July (C. H. Kennedy); New Hampshire, Mt. Washington; New York, Ithaca, Axton, Jamaica, Wells, Elm Lake, Newport, Poestenkill, Chapel Pond,

Johnstown, Poughkeepsie, Adirondack and McLean Bogs, Tompkins County, June to August; Ohio, Cedar Bog, Urbana (C. H. Kennedy), Salineville and Hocking County, June; Pennsylvania, Philadelphia and Jeannette, June; Rhode Island, Kingston, August 8, 1907; Manitoba, Aweme, June (E. Criddle); Quebec, St. John's County, July (Chagnon).

***Macrophya trisyllabus* var. *sinannula* new variety.**

Female.—In structure similar to the typical form of *trisyllabus*, but a trifle smaller in size. Differs in color in lacking the V-spot on the anterior lobe of the mesonotum and lacking the white transverse bands on the apical margins of the abdominal terga. The pronotum may also be entirely black. The venter of the abdomen, as in the typical form, may be entirely black or with some white transverse markings at the apices of the segments.

Male.—Similar to female, except that, as also in the typical form, the venter of the abdomen is well marked with white.

Holotype.—♀, Edmonton, Alberta, June 16, 1926 (E. H. Strickland).

Allotype.—♂, same data as holotype.

Paratypes.—7 ♂♂, 5 ♀♀, Gull Lake, Alta., June 8 to 26, 1929 (E. H. Strickland); 1 ♂, 1 ♀, Edmonton, Alta., June 16, 1926 (E. H. Strickland); 1 ♀, Edmonton, Alta., June 13, 1929 (E. H. Strickland); 4 ♀♀, Aweme, Man., June 25 to July 8, 1913 (E. Criddle); 1 ♂, 1 ♀, Algonquin, Ill. (Nason); 1 ♀, Oakwood, Ill., June 22, 1930 (H. H. Ross); 2 ♀♀, Orono, Me., July 11 to 15, 1913; 3 ♂♂, Mackinac Island, Mich., July, (C. H. Kennedy), 1 ♂, 3 ♀♀, Ithaca, N. Y., July 2 to August 20, 1918; 1 ♀, Cranberry Cr., N. Y., June 22, 1914; 1 ♀, Old Forge, N. Y., July 13, 1905.

The variety as limited in the above description seems to be the form of the species occurring in the more northern localities of the continent. It is given a varietal name because of its apparent geographical significance and because in determinations it has been confused with *M. niger* Nort. and *M. varius* var. *nordicola* Ross, from which it is readily separated by characters given in the following key.

The nearctic species of **Macrophysa** in which the antennae have a group of white apical segments may be separated in the female sex by the key given below.

1. Dorsum of abdomen entirely black except sometimes for a slight fuscous area in middle, or black with white marks..... 2
Abdomen with at least one or two tergites entirely rufous..... 7
2. Scutellum black..... **niger** Norton
Scutellum entirely or partly white..... 3
3. Hind femora with at least ventro-lateral portions rufous, dorsal portions sometimes black; middle portion of tibiae rufous or blackish rufous, **varius** var. **nordicola** Ross
Hind femora and tibiae without rufous, being a combination of black and white..... 4
4. Hind tibiae with a large white spot on the dorso-apical region, **oregona** Cresson
Hind tibiae entirely black..... 5
5. Extreme dorsal angle of meso-episternum and a spot below it on pleurae, white, the two spots sometimes coalescing, the lower one sometimes indistinct; annulations on apical margin of abdominal terga, if present, narrow, reduced or interrupted on meson..... **zonalis** Norton
Pleurae entirely black; white annulations on terga, if present, usually enlarged on meson to produce triangular marks..... 6
6. Anterior lobe without a white V-spot; dorsum of abdomen entirely black..... **trisyllabus** var. **sinannula** Ross
Anterior lobe with a V-spot; some tergites of abdomen usually with a transverse white line or transverse dots on apical margin, rarely entirely black..... **trisyllabus** (Norton)
7. Meso-episternum with a large white spot, occupying about half its area, **fascialis** Norton
Meso-episternum black, at most with a minute pale spot..... 8
8. Hind femora with apical half of posterior aspect black; entire basal half white, apical half usually entirely black except for extreme apex, which is always ringed with pale; anterior face of hind femora sometimes pale..... **fascialis** var. **puella** Ross
Hind femora without black on posterior face; usually entirely rufous or yellowish rufous in color, paler towards base; sometimes with a small amount of black which is in the form of a very narrow ring around extreme apex..... 9
9. Coxae rufous..... 10
Coxae black at base..... **varius** var. **eurythmia** Norton
10. Abdomen entirely rufous..... **varius** (Norton)
Abdomen with apical three or more segments black, base rufous, **varius** var. **festana** Ross

CONTRIBUTION TO THE BIOLOGY OF THE HALIPLIDÆ (COLEOPTERA).*

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The literature contains several scattered references to the biology of Haliplidæ. Except for the work of Matheson (1912, 156-193) and Wilson (1923, 231-345) on a few species, no extensive study of these beetles in America has been made. In connection with some life history (Hickman, 1930, 399-424) and experimental work (Hickman, in press) on haliplids, data were accumulated which seem worthy of publication. The beetles studied were found in the vicinity of Ann Arbor and of Douglàs Lake, Michigan. In order to work out the life histories, it was necessary to develop culture methods by which the development could be carried through from the egg to imago. Such methods were discovered and the complete life cycles of all species known in Michigan were worked out.

The author wishes to express his indebtedness to Professor Paul S. Welch, under whose direction this study was made; to Professor George R. LaRue, director of the University of Michigan Biological Station, for the courtesies extended while working in the Douglas Lake region; and to various other persons for materials and assistance

REARING METHODS.

The problem was first attacked by trying to keep the adults in the laboratory until egg laying time. After considerable experimentation, methods were found by means of which it was possible to maintain these insects the year around. Beetles collected in the field were separated, according to species, into finger bowls containing water, but not more than a dozen individuals were put in one bowl. Cistern water was used for the cultures of all the stages, although from experiments it appeared to have no particular advantage over tap, pond or distilled water. A little muck was placed in the bottom of

*Contribution from the Zoological Laboratory and the Biological Station of the University of Michigan.

the bowls in order that the beetles might hide in it when disturbed. Branches of *Elodea*, *Chara*, or *Ceratophyllum* were also introduced so that they could have a place on which to oviposit. The plants mentioned were never changed during the winter. Water was added about every month to replace that which had evaporated. During the summer, changes were made whenever the water became foul, at times as often as once a week. Temperatures up to about 75° F. had no detrimental effects, winter or summer, but much higher temperatures were destructive. Food was furnished not oftener than once a month during the winter since the beetles require little at this season, and the food will remain in good condition for a long time. During the summer, these conditions are reversed. The beetles require more food because they are more active and the food will soon deteriorate in warm water. As often as every other day a little food was added. The kinds of food will be discussed under a later topic.

When eggs appeared, they generally were removed to separate finger bowls which contained water. Removing the eggs from the water did not seem to do any damage. The temperature was maintained at about 70° F. No particular attention was given them until hatching time. Very few eggs failed to hatch.

The larvæ were very easy to rear in the laboratory when a few essential factors remained about constant, such as food, temperature, and condition of the water. They were separated into stender dishes which contained water to a depth of about one inch. Each larva was isolated in a dish. During the warm days of summer when the temperature was much above 75° F., the water was changed daily and all unconsumed food removed. The water was either removed by means of a large pipette or the larvæ were removed to new cultures by use of forceps. In order that the condition of the cultures dishes could be observed easily, they were arranged on a shelf one row deep. Covers were placed on the dishes to check the evaporation of the water. They were never exposed to the direct sunlight.

The pupa was the most difficult stage to obtain because the larva will not pupate unless conditions are right. Instead, it would remain as larva or would die. Nevertheless, the pupæ of all the different species were secured. When the larvæ

had reached the third instar they were transferred to a smaller stender dish containing a little water and food. A branch of water plant was so arranged that it extended over the top of the dish in order that the larvæ could crawl out to pupate. This small dish was placed inside of a larger stender dish which contained a small amount of earth. This earth had been taken from the shore of the lake in the vicinity of the place where they naturally would pupate. Before they would enter this earth the latter had to have the right moisture content. This seems to be the most important factor. If it was too wet or too dry they would not construct the pupa chamber. It was found that if the earth was just damp enough to hold together, the larvæ would pupate. A few drops of water were added from time to time to prevent undue drying. Fungus growths had to be watched for and eliminated. They were largely avoided at the outset by moistening rather large quantities of this shore material, allowing it to stand for a few days before using, and selecting those samples which showed no fungus growth.

BIOLOGY OF THE IMAGO.

Although the general environment of these beetles has been known for a long time, yet, it seems proper to analyze the habitats a little more in detail. Generally speaking, adult haliplids are found in standing water or slow streams where the proper food is found. They are not adapted to swift currents, as they can not swim fast enough to make any headway. The habitats might be enumerated as follows: pools; deep, slow moving streams, protected places along rivers; roadside pools; ponds; and protected places in lakes. In fact, they were always found where their food occurred, and since all of the different kinds of food are not found in all the places mentioned above, there would necessarily be a limitation as to which species might be present. Within the usual limits, such factors as pH, dissolved oxygen, and transparency seem to have no effect on the distribution. *II. immaculicollis* Harr was more generally found in the smaller ponds and pools. *II. cribrarius* Lec. occurred only in the slightly deeper water of lakes among the *Chara* and *Nitella* beds, and was the hardest to collect for this reason. Some were taken under 6 feet of water, and they might have been taken in still deeper water had the special

effort been made. *H. triopsis* Say is another lake form found among the *Elodea* and *Chara*, but was taken often near the shore in shallower water. *Peltodytes sexmaculatus* Rbts., and *P. edentulus* Lec. were cosmopolitan in distribution as they were found in all the above listed places. In the vicinity of Ann Arbor, *P. lengi* Rbts. is restricted to the Huron River and its branches, although no reason can be given for this selected habitat.

Matheson (1912, pp. 181-182) and Leng (1913, p. 33) have discussed the structural adaptations of these beetles for aquatic life and further comment seems unnecessary except to mention another function for the posterior coxal plates. It has been already stated by many investigators that these plates retain an air store but experiments discussed in another paper (Hickman, in press) showed that the expanded coxal plates enable the beetle to hold a bubble of air for the purpose of tipping the apex of the abdomen through the surface film.

Not much can be added to what is already known concerning the locomotion of these beetles. They are poor swimmers although the tarsi of the second and third legs are provided with a fringe of long setæ. That they swim with ambulatory movements was definitely proven by means of motion pictures. They spend most of their time while in water walking over the vegetation and swimming short distances. On land, they are good walkers and can run with some speed. They can fly as shown by the fact that they have been taken at electric lights (Knaus, 1899, p. 110). In the laboratory, they very often will leave the cultures and fly to a desk light.

Several investigators have observed that the beetles of this family are not carnivorous as was generally thought, but are herbivorous. Matheson (1912, p. 182) was the first to observe that they feed upon plants. He states "In my aquarium *II. ruficollis*, *II. connexus* and *II. cribrarius* were observed feeding greedily on the contents of *Nitella*, the softer portions of *Chara* and other filamentous algæ." Some years later, Pearce, (1921, p. 184) in speaking of the food habits of *Haliphus*, writes "In each case the specimens fed happily on the algæ, and were not observed seeking for animal food." Wilson (1923, p. 273) makes a rather definite statement about the food habits of *Peltodytes edentulus* Lec., "as far as observed they feed entirely upon *Chara* and *Nitella*" and also the same kind of statement

for *H. ruficollis* DeG. "They feed exclusively upon filamentous algæ." Falkenström (1926, p. 15) reached the same conclusion "Infolgedessen glaube ich feststellen zu können, dass nicht nur *H. immaculatus*, sondern auch mehrere andere Haliplidenarten, wenn nicht alle, Algenfresser sind, und dass sie nur in Ermangelung der Algen oder vielleicht anderer geeigneter Wassergewächse bei störkerem Hunger animalische Nahrung ergreifen." The author's observations and results of various tests are in agreement in part with the above statements. Since the beetles will live a long time without apparent food, the problem was a very difficult one to solve. Records were obtained which showed that the beetles lived as long as a month and one-half in filtered, cistern water. Nothing was unusual about the habits of the beetles during the starving period up to a few days before death. So it was difficult to determine when they were receiving the proper nourishment. Great numbers were lost at first because from their behavior it was taken for granted they were getting the proper food. This seems to have been the same error made by other investigators. By means of an elimination test certain facts were obtained for the different species. Various kinds and combinations of aquatic plants and animals were tried. Such plants as *Spirogyra*, *Eloдея*, *Chara*, *Nitella*, *Ceratophyllum*, *Lemna*, *Juncus*, *Ulothrix*, and unicellar algæ were used. Animals such as *Tubifex*, snails, Entomostraca, fresh beef, various insect larvæ, and dead beetles of the same family were also offered to the beetles as possible food. Although, when starved for a few days, they would attack and eat animal substances, but they were not kept alive very long on that kind of a diet.

Spirogyra proved to be the only kind of food that gave satisfactory results for four species, *Peltodytes edentulus* Lec., *P. sexmaculatus* Rbts., *P. lengi* and *Haliplus immaculicollis* Harr. Beetles of these species have now been kept living on this kind of food for eighteen months. During this time, they have laid eggs that hatched. *Nitella* was the only food that gave successful results for *Haliplus cribrarius* Lec., and *H. triopsis* Say. They have been kept alive for about nine months. The possibility that, in nature, other substances may be taken as food, is not necessarily ruled out, but satisfactory results have thus been obtained in the laboratory. With these things in mind it can be said that the beetles of the species studied are herbivorous and feed upon algæ.

No definite figures are known for the length of life of these beetles. The author kept beetles alive for eighteen months and they were still alive when the culture had to be discontinued. They were the first to be successfully cultured in the laboratory.

It was generally inferred that the beetles hibernate during the winter months, probably because they had never been collected. The author has collected them under 22 inches of ice, which had been on the lake for 3 months. The beetles were actively swimming about. While collecting through a hole in the ice individuals appeared at the surface and then dived. From the manner in which they came to the surface, it was decided that they must have had a bubble of air attached to the coxal cavity, otherwise, their behavior would have been entirely abnormal as has been shown in a previous paper (Hickman, in press). The question as to where they get the oxygen necessary for their activities during the winter has never been satisfactorily answered. Several theories have been advanced. Scott (1910, pp. 35-36) thinks that the filamentous algae produce oxygen and that the *Typha* stems allow some gaseous exchange with the atmosphere. Wesenberg-Lund (1913, pp. 44-45) states that the aquatic beetles will collect in places where there are many green water plants and that they make use of the oxygen given off from them. The author's collecting experiences confirm Wesenberg-Lund's statement of the beetles' congregation at places where there are numerous green aquatic plants. Some of the largest collections made at one time were secured at such a place in the month of December. For example, during the past two winters, the beetles have been taken in numbers very much greater than during the summer at a patch of *Juncus* (bog-rush). Whether there is any connection between this particular water plant and the over-wintering of the beetle is not known. They are, however, very resistant to freezing, as tests in the laboratory show that they can be frozen solid in ice and still live. One test showed that beetles alternately frozen during the night and thawed out during the day over a period of twelve days were still alive. How long they could endure freezing is not known.

These beetles are not fast swimmers, a fact that Matheson (1912, p. 182) has already stated. "The swimming efficiency is very feeble as compared with the more specialized Dytiscidæ.

Instead of a soldering fast of the posterior coxæ and the formation of a solid joint, as in the Dytiscidæ, there is a remarkable plate-like development of the coxæ. By this means the hind legs are moved in one plane and their efficiency as swimming organs increased though their horizontal range of movement is, if anything, lessened." They will go to cover when disturbed and dig under the leaves or muck until they are hidden. Also they spend most of their time walking about over the vegetation rather than swimming. In this way they are not very noticeable and their larger enemies probably have more difficulty in finding them than if they were in open water. They have the death feigning habit and will remain motionless for a period of from a few seconds to several minutes when touched. This is a very good protective habit when out of the water as they sometimes are.

As early as 1880, Forbes recorded that *Haliplus* was eaten by *Semotilus corporalis* Mitch., the eastern chub. McAtee (1918) found beetles of this family in the stomachs of three species of Mallard ducks. Mabbott (1920) states these beetles were common in the stomachs of seven species of shoal ducks. No great amount of work was done on this subject but a few observations were made. The stomach contents of a sunfish taken at Douglas Lake included the elytra of a *Peltodytes* species. In the laboratory, they were eaten by frogs, *Dytiscus* adults and larvæ, and dragon-fly naiads. So it seems that most any aquatic insect eater might prey upon them.

In the course of dissecting some of these beetles there was found a stage of a water mite (*Hydracarina*) attached to the under side of the elytra. Pearce (1922, p. 37) had noticed the same for *Haliplus obliquus* Er. The author found them only in *Peltodytes edentulus* Lec., and *P. sexmaculatus* Rbts. The material was sent to Dr. Ruth Marshall, who identified and reported them (1927, p. 270) as the nymphal stage of *Eylais desecta* Koen. These water mites apparently do not seriously harm the beetles, as infested individuals isolated in November, 1926, are still alive (April, 1928). During the summer of 1927, these infested individuals laid eggs in the usual way. It seems likely that if the infestation be great they might interfere with the natural respiratory movements. Generally there is only one mite to a beetle but as many as six per host have been found.

The only record of copulation is that of Matheson (1912, p. 183, 186). He states that copulation takes place during the latter part of April and the month of May and that egg laying begins shortly afterwards. The author observed copulation in *Peltodytes edentulus* Lec., and *P. lengi* Rbts. in the last week of April and egg laying occurred one to two weeks later. Yet, a female beetle isolated in a culture in November of the previous year laid eggs about the 15th of May and normal larvæ hatched from them. It would thus seem that copulation took place as early as the fall before. Also copulation was noticed in the aquarium during the month of August for *H. immaculicollis* Harr. Still no eggs were laid in the culture that fall. More data are needed to clear up this point.

EGG-LAYING HABITS.

The period of egg-laying is very definite for the months of May, June and early part of July. There may be another one in the fall months as will be shown later in the discussion of the life cycle.

The number of eggs deposited by one individual varied from 30 to 40 but it was very hard to get a good count as they are not all laid at one time, but scattered over the period of a week or more. The time of laying varied greatly with different individuals. In a culture containing several females, eggs were collected from May first to July fifteenth and then only a few at a time.

The places where the eggs are laid are identical for the three *Peltodytes* species. They are laid on aquatic plants such as *Elodea*, *Ceratophyllum* and filamentous algæ. The previous statements are based upon field observations. In the cultures, they were laid on various things that might be in the aquarium. In several instances they were found on the long projections of *Peltodytes* larvæ which happened to be in the cultures with imagoes. There seemed to be no correlation of place of deposition with depth of water. Some were near the top and others under several inches of water. They were glued on one side to supporting objects but in no regular manner. *Haliplus immaculicollis* Harr. laid its eggs in holes which it cut in the stems of *Ceratophyllum*.

The process of egg-laying was observed but once and that for *Peltodytes lengi* Rbts. The female hunted around over the

branches until a suitable place was found and then deposited an egg. Actual laying required only a few seconds. Then the female moved a little and deposited another one. There seemed to be a sticky substance on the egg when first deposited which held the egg fast to the stem. This substance was all over the egg as instances were found where it was glued to more than one branch.

The chorion is sufficiently transparent to allow observations on development. After about 5 days, the six ocelli were observed as dark pigment bodies on each side of the egg. This fact was also observed by Falkenstrom (1926, p. 20). A few days later, faint outlines of body structure appeared. The larva lay on its back in the egg and the anterior and posterior ends were folded back upon the ventral surface. Body structures became more distinct up to the time of hatching and served as an indication of the hatching time, which took place about 8 to 10 days after oviposition.

The larva broke out slowly through a longitudinal slit which extended over the anterior end and more than half-way down each side of the egg. Those observed required about 3 hours from the beginning of hatching until they were free.

HABITS OF THE LARVA.

Larvæ of *P. edentulus* Lec., *P. sexmaculatus* Rbts., *P. lengi* Rbts. and *H. immaculicollis* Harr. were found among masses of filamentous algæ. At times they also occurred where no algæ were present, but this could be understood from the behavior of the algæ. Filamentous algæ, especially *Spirogyra*, are rather fast in growth and also fast in disappearance. Therefore on one date there might be a lot of the algæ at a particular spot and a few days later apparently none. Larvæ of *Haliplus cribrarius* Lec., and *H. triopsis* Say were taken only in *Chara* and *Nitella* beds and were therefore more restricted in habitat.

The larvæ are adapted only for crawling, and are very slow in their movements. Instead of hastening away when disturbed they will curl up and remain so for some time (3 to 6 minutes). They can not float but must reach the surface or shore by crawling over the vegetation or bottom.

The food without a doubt is algæ. The species of *Peltodytes* and *Haliplus immaculicollis* feed exclusively on filamentous algæ. The first pair of legs are particularly adapted for this

kind of food. By means of these legs they grasp the filament, pass it back in a hand-over-hand fashion until they reach the end. Then, they push it forward, at the same time puncturing each cell and sucking out the contents. They are very rapid feeders, and consume great quantities of algæ, especially when the larvæ are in the first and second instars. *Ialoplus cribrarius* Lec., and *II. triopsis* Say feed upon Chara and Nitella, although in an entirely different manner. Their first pairs of legs are not adapted for grasping and passing the food to the mandibles as was previously stated for the filamentous algæ feeders. In fact, since Chara and Nitella are attached plants, they could not be so handled. Instead, the larvæ, after selecting a place to feed, scrape off the outside layer of the branches with the mandibles by means of a downward movement of the head, at the same time drawing in the loosened material through the suction canals. They usually begin to feed anywhere on the branches and make no effort to remove all of the layer but only in patches. Any slight disturbance in the cultures will stop them from feeding and many seconds usually elapse before beginning again.

The first and second larval instars are without spiracles so they must receive their oxygen by cutaneous respiration. The third larval instar of all the species studied has open spiracles and those of *Peltodytes* have the tracheæ extending out into the long body projections. These projections can be clipped off and still the larvæ will pupate. For that reason they must not be of vital importance. The third larval instar of *Peltodytes* species was thought not to have spiracles, but Steinke (1919, pp. 10-11) found them and the author has confirmed his results.

Only inferences can be stated about their protection. Presumably, the filamentous algæ feeders receive some protection by living on and within the algæ masses. They are not readily seen and their enemies are perhaps hindered by the strands from moving readily in search of these larvæ.

The *Chara* and *Nitella* feeders, it would seem, are protected from enemies by coloration and body forms, which are very similar to that of the plants. Also they are not easily detected by their movements as they are very slow crawlers.

Three instars are typical for beetle larvæ and it is very easy to distinguish them because the body projections become more complex for each instar. Head dimensions and total lengths

also are very dependable as characters for separating the instars.

Ecdysis was similar to that of other aquatic larvæ. A break in the skin occurred along the epicranial suture and extended posteriorly through the mid-dorsal line of the prothorax, mesothorax and metathorax. The process was very slow and required about two hours.

Generally speaking, of the beetles reared in the laboratory, the first larval stadium lasted about 5 to 7 days; second, 6 to 8 days, and third, 5 to 10 days. Very few larvæ died in the cultures even during the difficult and critical process of ecdysis which is some indication that the stadia were of normal duration. The last larval stadium may be much longer if conditions are not optimum for pupation. Many things prolonged these periods, such as starvation and low temperature. These stadia were about the same as reported by Matheson (1912, pp. 183-187).

Larvæ of the genus *Haliplus* were collected during the winter months and since the larvæ of all Michigan species were kept alive in the laboratory until February or later, it would seem that they will pass the winter in active form if conditions prevent them from pupating before cold weather appears. On December 19, 1927, larvæ of the second and third instars were taken under the ice at Geddes Pond. Second instar larvæ had not changed to the third larval instar as late as April 13, 1928, although they were kept in the laboratory at room temperature. Falkenstrom (1926, p. 12) states that for the most part they spend the winter above the water. The author's results do not confirm this statement.

The greatest enemy is probably fish, especially the minnows that live around among the algæ where the larval period of the beetle is spent. Wilson (1923, p. 260) gave evidence for this statement. Other things have attacked them in the laboratory, such as carnivorous insect larvæ and frogs. This suggests that possibly they are likewise enemies in nature. Various mites, crustaceans, and other organisms run over them, although no great harm was ever done in the cultures. In summer, enchytraeids were often wrapped around the larvæ, but there was no sign of resulting harm. On the whole, they were rather resistant to the smaller enemies. One added advantage is the fact that the larvæ are free from cannibalism and any number can be kept together.

A few days after the third larval instar was formed the larvæ began to wander about the culture apparently trying to get out. When allowed to get to shore material, they began to select the proper place in which to dig. After burrowing below the surface, up to a depth of one inch, they made a round cavity by digging the earth away and trampling it down. It required from one to three days to construct the chamber. After finishing the cell they curled up in the form of a semi-circle with the dorsal side resting on the floor of the cell and remained in this position for 2 to 4 days previous to pupation.

THE PUPA.

The pupal period was 12 to 14 days. Although the pupa was completely buried and was in the dark, these conditions were not necessary for its development. Some of the cells were uncovered and exposed to light, yet the pupæ transformed normally.

Several times a cell was uncovered at the time of transformation. The pupa is a typical exarate type and the process of changing to adult is very similar to other beetles. Time required by the pupa to shed the exuvia is about twelve hours from the first apparent sign of activity to the end of process.

LIFE CYCLE.

It has been definitely proven from cultures and field collections that there is a summer generation which includes the months of May, June, July and the first part of August for all the species studied and there are indications of another generation that begins in the fall and extends over to spring. For the summer generation, eggs are more numerous during the first part of May but may be found as late as the middle of July. Larvæ appear after about eight days and remain in the water at this stage for about three weeks including all instars. Then the larvæ seek the shore to pupate. The interval required from the time the larvæ enter the ground to their emergence is about two weeks. The imagoes seek the water immediately after leaving the pupa chambers. This whole period from egg to adult is about six weeks.

There may be another fall generation from the fact that larvæ of the second instar were collected in December and remained as such in the laboratory until the following April.

Summer collecting gave no indication that the earlier instars would remain that long. It was noticed while collecting at a particular spot that on one occasion a great majority of larvæ were taken in the first instar. A few days later, the greatest number were larvæ of the second instar and still a few days later the larvæ were almost all third instars with a few second and no first instars. It seems that this is a check on the data from laboratory cultures. However, the larvæ on the first and second instars never prolonged their period even when food was scarce, but the third instar will continue as such if not given a chance to pupate. The larvæ of the second instar, collected in December, were kept under the same conditions as the summer larvæ, yet the stadia were prolonged. Why was it prolonged in the winter and not in summer? The answer is not known but it would seem that it was due to something within the larva and not to outside factors.

Falkenström (1926, p. 13), unsuccessful in having the larvæ pupate under laboratory conditions, came to the conclusion that they do not naturally pupate during the same summer in which they are hatched. He states: "Die Larven erreichen während des Sommers ihres Ausschlüpfens nicht die Reife, um die Metamorphose durchmachen zu können, sondern überwintern als Larven in verschiedenen Stadien."

As already indicated, the author's findings are entirely different from those of Falkenström and confirm even more definitely the earlier proposal of Matheson (1912, p. 191): "There is probably more than one brood a season."

It may be that Falkenström's difficulty in getting the larvæ to pupate was due to faulty culture methods, as the author has already stated that he himself experienced the same thing at first. However, when conditions were right the larvæ would pupate.

CONCLUSION.

1. Culture methods were developed for keeping the imagoes alive in the laboratory the year around, and for rearing these beetles from egg through all of the life history stages.

2. Imagoes and larvæ of the three species of *Peltodytes* and of *Haliplus immaculicollis* feed upon filamentous algæ, especially *Spirogyra*. *H. cribrarius* and *H. triopsis* feed upon *Chara* and *Nitella* in both mature and immature stages.

3. There is definitely one generation in the summer, and evidence of a fall generation that extends over to the following spring.

4. Both imagoes and larvæ spend the winter in the water, and manifest the same activities as during the summer.

5. The duration of the third larval instar can be prolonged for nine months or longer by keeping the larvæ in water and preventing them from reaching soil to pupate.

6. Nymphs of a water mite, *Eylais desecta* Koen, were found attached to the under side of the elytra of *Peltodytes edentulus* and *P. sexmaculatus*.

BIBLIOGRAPHY.

- Bertrand, Henri.** 1928. Les Larves et Nymphes des Dytiscides, Hygrobiides et Haliplides. Encyclopédie Entomologique, 10: 366 pp., 33 pls., 207 figs.
- Brocher, Frank.** 1912. Recherches sur la respiration des insectes aquatiques adultes. Les Elmides. Annales de Biologie Lacustre, 5: 136-179, 23 figs.
1922. Observations biologiques sur les Haliplides (Coleopteres). Annales de Biologie Lacustre, 11: 7-18, 2 figs.
- Falkenstrom, G.** 1926. Beitrage zur Kenntnis der Biologie der Halipliden und der Metamorphose von Haliphus immaculatus Gerh. Entomologisk Tidsskrift, 47: 1-28, 8 figs.
- Hickman, Jennings R.** 1930. Life-Histories of Michigan Haliplidae (Coleoptera). Mich. Acad. Sci. Arts and Letters, 11: 399-424, 9 pls.
- The Respiration of the Haliplidae (Coleoptera). Mich. Acad. Sci. Arts and Letters. (In press).
- Marshall, Ruth.** 1927. Hydracarina of the Douglas Lake Region. Trans. Amer. Micro. Soc., 46: 268-285, 32 figs.
- Matheson, Robert.** 1912. The Haliplidae of North America, north of Mexico. Journ. of the N. Y. Ento. Soc., 20: 156-193, 5 pls., 3 figs.
- Pearce, E. J.** 1921. Haliphus as vegetarians. Ento. Mo. Mag., 57: 184.
1922. Haliphus obliquus Er. infested with acarid parasites. Ento. Mo. Mag., 58: 37.
- Scott, Will.** 1910. The Fauna of a solution pond. Proc. of the Ind. Acad. of Sci., 24: 1-48.
- Steinke, Gerhard.** 1919. Die Stigmen der Käferlarven. Archiv für Naturgeschichte, 85: Abt. A. Heft 7: 1-58, 42 figs.
- Wesenberg-Lund, C.** 1912. Biologische Studien über Dytisciden. International Review der gesamten Hydrobiologie und Hydrographis, 5: 1-129, 9 pls. 5 figs.
- Wilson, Charles Branch.** 1923. Water beetles in relation to pondfish culture, with life histories of those found in fishponds at Fairport, Iowa. Bull. U. S. Bur. of Fish., 39: 231-345, 148 figs.

KEY TO KNOWN PUPAE OF THE GENUS CALENDRA, WITH HOST-PLANT AND DISTRIBUTION NOTES

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INTRODUCTION.

The preparation of a table or "key" for determining the several species of beetles of the rhynchophorus genus *Calendra** in the pupa stage has been necessary in order to facilitate the study of the species involved in economic outbreaks.

This key has been in use at the Webster Groves, Missouri, field laboratory of the Bureau of Entomology since the winter of 1923-1924, and has evolved to its present state through adjustments made for the accommodation of additional species and of variants within species, as required by the increase in material at hand. Further changes in it will be necessary as knowledge of the pupa stage progresses.

The notes on geographical distribution given herein are only those gleaned by the writer from data attached to specimens of the species included in the present list of pupæ. These were either generously submitted by institutions and private collectors for study, or were obtained in the course of investigations in the field.

The arrangement of species of plants in the appended host-plant and plant-host lists is according to Gray's New Manual. The arrangement of the species of *Calendra* is according to Leng's List, with the possible exception of the place chosen for one form described since the List was published.

Descriptions of the pupa of each species are given, with a summary of the details used in the key for the species, followed by the description of one specimen of the species, in turn followed by the minimum and maximum measurements for the species, with average measurements and the number used in arriving at the averages.

Our knowledge of the geographical distribution of most species of *Calendra* is very incomplete and in only certain species has any definite value in this key. The apparently restricted occurrence of *Calendra phoeniciensis* in Arizona and of *C. discolor* in California and Oregon, will probably hold true only until a fairly careful survey is made of regions possessing similar ecological associations elsewhere. The occurrence of *C. ludoviciana* along the Gulf Coast and in southeastern Missouri indicates that little is known of billbug distribution

*Formerly *Sphenophorus*.

in the zone lying between the coast line and the latitude of Missouri, especially as the region includes the bottoms of several sluggish tributaries of the Lower Mississippi River. The occurrence of *C. retusa* in Florida, New Jersey and Massachusetts, may bear a consistent relationship to coastal distribution, but the seasonal occurrence of pupæ cannot be expected to be similar in the remote latitudes.

DISCUSSION OF CHARACTERS.

The genus *Calendra* comprises a taxonomically difficult group of destructive insects popularly known as "billbugs." It consists of seventy-five or more species within the United States and numerous other species not occurring in this country. Distinguishing characters in the adult stage are often obscure, and in the pupa stage are fairly liquid.

Size in these insects, which dig their livelihood out of the interior of short-lived plants, is particularly variable. If the plant dies before the immature insect is sufficiently near maturity to complete its development, the insect must migrate to other food or die. Nature allows the insect some leeway, however, in the matter of development and it can mature with reduced growth in the event of reduced food. As a consequence, although the adult females average larger than the males, some females at maturity are much smaller than the average males and there is nearly 100 percent difference in length between the smallest and the largest billbugs of the same sex and the same species. Like variation must be expected in the pupæ of these insects.

The season of occurrence of the pupa stage has not been utilized in the key, because the differences of season in the latitude of St. Louis and northward are insufficient to have real value, and the geographical distribution aids directly in the differentiation of those species which extend far enough south to be seasonally different.

A study of the distinguishing characters in the pupæ of the species of *Calendra* could not profitably be conducted until many specimens known to be of one species could be analyzed and a fair valuation of characters thus be established.

Numerous adults of *Calendra retusa* were obtained in 1922 and 1923, from which many eggs were obtained and pupæ reared. Descriptive notes were made of over one hundred

pupæ of this species and an attempt was made to count and tabulate all setæ borne by every anatomic part. The dorsal setæ of the first six abdominal segments and all lateral setæ, except in some instances the stigmatal setæ of the pronotum, are ignored as having insufficient value to merit counting. The dorsal setæ located on the seventh and ninth abdominal segments are usually eight or ten, in groups of four or five, and are rarely of specific value.

The setæ which have proved most nearly constant are those of the rostrum, pronotum, mesonotum, metanotum, and eighth tergite.

The setal armature of the rostrum consists of two, three, four, or five pairs, regularly spaced, sometimes with promiscuously placed extra setæ. The number most frequently observed is three pairs, the basal often arising from conspicuous prominences or irregularly wrinkled areas located nearly over the posterior extremities of the compound eyes. The apical pair of the three-pair set is placed on the arch of the antennæ, usually posterior to the point of attachment of the antennæ. When the armature is limited to two pairs, the basal of the three-pair set is wanting and the positions of the two remaining pairs continue as before. When one or more pairs are added in regular spacing, they are located between the antennal arch and the apex of the rostrum.

Each seta has a conical base, sometimes somewhat flattened transversely, almost always smooth. The basal setæ may be located on a smooth contour of the head, or on the prominences previously mentioned. These prominences afford aid in the determination of many of the species included in this paper. They are elusive, in that they vary from a practically plain contour to a group of miniature tubercles in *pertinax*, or they may be high, almost cylindrical, excrescence-like, as in *melanocephala*, broad and overhanging laterad, as in *ludoviciana*, broad and nearly circular, or narrow, transverse oval areas. The degree of height in the broad prominences is difficult to define. Variations within species have necessitated keying out several species at two or more places.

On the pronotal disc are paired setæ at the four front and back corners, and at the middle. These are designated, respectively, "pro-latero-pronotal," "postlatero-pronotal," and "medio-pronotal" setæ. There are usually two pairs of pro-latero-pronotals and of postlatero-pronotals and rarely two pairs, usually one pair, often no pair of medio-pronotals.

On the sides of the pronotum there are usually two pairs of fine setæ, the "spiraculo-pronotal" setæ. Frequently these are so fine as to defy discovery except with high magnification, good illumination, and more patience than this character merits. However, in some species the spiraculo-pronotals are as large as the largest on the disc, and sometimes the location of one or both pairs will be at the edge of the disc or conspicuously separated from each other, or one pair will be conspicuously close to the outer postlatero-pronotal setæ.

On the mesonotum and metanotum there are generally two pairs, varying from none to three or four pairs on one or both.

On the eighth tergite there may be two setæ, sometimes as large as the largest on the seventh or ninth, two spots indicating that setæ had been there, or ought to have been there, or no trace of setæ. In some species there are usually several small setæ in addition to the large setæ, if the latter are present.

The length of the rostrum is measured by its termination at the cephalic margin, at the middle, past the middle, or beyond the caudal margin of the apices of the first pair of tibiæ.

The measurement of width of pronotum is the greatest width across the disc, without regard to the appendages. The total length is normally that at which the pupa will cease to be held between the jaws of the caliper at the up-turn of the measurement screw. It is possible that the setæ may serve to a slight extent to retain the pupa in the caliper beyond the actual measure of the flesh, but the correction of this small error was impracticable.

A word concerning the caliper used may be helpful. It is a sliding type for outside and inside calibration to 0.01 mm. To avoid error by reason of looseness, all measurements are taken on the up-turn from a starting point of tight contact of the jaws, opening at zero. The calibration on the bar is to 0.5 mm., for 10 cm. The adjustment for the reading is by a thumb screw graduated to fiftieths and makes one cycle to each 0.5 mm.

The determination of the sex in the pupa is made chiefly on the presence of a longitudinal impressed or stained line on the ventral surface, basal half, of the ninth segment, but sometimes reaching across the eighth and onto the seventh sternite. This line is absent in the male. Well-marked females have a pair of blunt conical projections on the ventral surface, just cephalad of the clusters of setæ of the ninth tergite. As the pupa nears maturity, the terminus of the pygidium and of the eighth tergite often shows the truncate character of the male or the acuminate character of the female.

Color does not appear to have specific value. All the pupæ are white, wood ivory, or creamy white, varying somewhat with age, possibly with environment, but chiefly with age. The prominences upon which the basal tubercles of the rostrum develop, color up in a few species, notably in *callosa* and *setiger*.

DESCRIPTION OF PUPÆ.

Calendra inaequalis (Say).

Rostrum with six regular, seta-bearing tubercles, with or without additional, promiscuously placed, seta-bearing tubercles, the basal pair set on broad, irregular prominences, moderately high and moderately wrinkled; two large medio-pronotal setæ; four large and two small spiraculo-pronotal setæ; all setæ conspicuously barbed; length, 7.81 to

8.25 mm., average (2), 8.03 mm.; pronotal width, 2.78 to 2.98 mm., average, 2.88 mm.

Female. Length, 8.25 mm.; pronotal width, 2.98 mm. Rostrum with seven conical, seta-bearing tubercles, basals on narrow, oval, low prominences, transversely placed; surface irregular, the irregularities somewhat regularly transverse, and becoming transverse rings from apical tubercles to apex of rostrum; a median line from basals to a point two-thirds forward from second to third pairs of tubercles. Apex above scarcely concave. The seventh seta-bearing tubercle is placed cephalo-mesad of the middle left tubercle, and is very small. Rostrum robust, short, extending about one-third across the protibiae. Basal setae set much closer to each other than are the individuals in the other pairs; longitudinal spacing uniform. Prolatero-pronotal setae, four; postlatero-pronotal setae, four large setae and, on right, a small extra seta; medio-pronotals, two; spiraculo-pronotals, four large and two small setae; mesonotals, four; metanotals, three left, two right; setae of eighth tergite wanting. All setae are strongly barbed. Those of thorax are all notably coarse, except those noted as small. The spiraculo-pronotal setae are two coarse setae set close together on edge of pronotal disc, each side, and one small seta each side, much nearer the spiracle. The regular postlatero-pronotal setae are widely separated; the supplementary seta is near the left, outer postlatero-pronotal seta. The medio-pronotals are only slightly caudad of line between posterior setae of the prolatero-pronotals. The mesonotal and metanotal setae are unusually large and closely set on their respective areas. The tips of the elytra are strongly developed, not so vertical as in some species, but the portion caudad of the point is bent back strongly toward body. The pupa appears robust.

Description from reared live pupa, specimen 28110a.

Calendra aequalis (Gyll.).

Rostrum with six seta-bearing tubercles only, all conical, basal pair set on broad, irregular prominences, high, deeply wrinkled, sides rounded, or not set on such prominences; mesonotal setae usually four or more, sometimes two; medio-pronotal setae rarely more than two, occasionally wanting; setae of eighth tergite wanting; length, 14.77 to 23.00 mm., average (12), 18.49 mm.; pronotal width, 4.36 to 6.49 mm., average, 5.73 mm.

Male. Length, 17.52 mm. Rostrum with six conical, seta-bearing tubercles, the basal pair set on irregular prominences. Prolatero-pronotal and postlatero-pronotal setae, four each; medio-pronotals, two; spiraculo-pronotals wanting; mesonotals, six; metanotals, four; setae of eighth tergite wanting.

Description from preserved wild pupa, specimen 22717. See dorsal and ventral views of this male and lateral and ventral views of a female from same collection, Pl. I, Figs. 1-4.

Length, from 14.77 to 23.00 mm.; average (7), 17.60 mm.; pronotal width, 4.36 to 6.49 mm.; average, 5.47 mm.

***Calendra discolor* (Mann.).**

Rostrum with six or more regularly spaced, seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, moderately high and wrinkled; two or more setæ on eighth abdominal tergite; no spiraculo-pronotal and never more than two medio-pronotal setæ; length, 11.66 to 19.00 mm., average (8), 17.26 mm.

Male. Length, 15.75 mm. Rostrum with eight conical, seta-bearing tubercles, basal pair set upon a wrinkled, fairly high prominence. Prolatero-pronotal setæ apparently six, but as the medio-pronotal setæ are not in the region of the median line, presumably they have migrated to the region of the prolatero-pronotals; postlatero-pronotals, four; spiraculo-pronotals wanting; mesonotals, two left, one right; metanotals, four; setæ of eighth tergite, three left, two right, all small.

Description from preserved wild pupa, specimen 21009bu, contributed by C. M. Packard, from tule marsh, Rio Vista, Calif. See illustrations, full dorsal and full lateral views and view of segments seven to ten, of abdomen, Pl. I, Figs. 5-7, respectively.

Length, 11.66 to 19.00 mm.; average (8), 17.26 mm.

***Calendra pertinax* (Oliv.).**

Rostrum with six regular tubercles or basal pair replaced with a rippled, slightly elevated contour of the head or with a cluster of miniature tubercles, only the cephalad four tubercles bearing setæ; basal pair of tubercles never tall-rosetted or excrescence-like, but resembling the forward ones if present.

Female. Length not recorded. Rostrum with basal tubercles fairly definitely defined, but with all tubercles small as compared with those of most other species; the four cephalad tubercles conical, seta-bearing. Prolatero-pronotal setæ three, two left, one right; postlatero-pronotals, four; medio-pronotals, spiraculo-pronotals, and mesonotals, wanting; metanotals, two; setæ of eighth tergite wanting.

Description from a wild, preserved pupa, specimen 1992t. See illustrations of this pupa, showing full side view and ventral or face view of head, Pl. I, Figs. 8, 9.

Length, from 10.99 to 16.12 mm.; average (20), 13.74 mm.; pronotal width, 3.44 to 4.52 mm.; average, 3.81 mm.

***Calendra setiger* (Chtttn.).**

Rostrum with only six seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, high, deeply wrinkled, overhanging laterally; mesonotal setæ, four; basal tubercles in their entirety appearing as hemispheres cut under at outer edge or circular with high vertical boundaries.

Female. Length, 13.21 mm.; pronotal width, 3.53 mm. Rostrum with six conical, seta-bearing tubercles, the basals finely wrinkled, set on deeply wrinkled, nearly hemispherical prominences, overhanging

cephalad-laterad, darker than rest of head, appearing to unaided eye as two projecting red points. Rostral setae uniformly large, second and third pairs in parallel lines, the basals wider apart. Apex of rostrum reaching slightly beyond the protibiae. Prolatero-pronotal and postlatero-pronotal setae, four each; medio-pronotals, two; spiraculo-pronotals, one left, two right; mesonotals and metanotals, each two; setae of eighth tergite merely indicated by two spots. The medio-pronotals are as large as the largest of the notal setae.

Description from living reared pupa, specimen 26037a.

Length, from 11.70 to 14.36 mm.; average (50), 13.09 mm.; pronotal width, 2.88 to 4.15 mm.; average, 3.61 mm.

***Calendra ludoviciana* (Chttn.).**

Rostrum with only six seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, high, deeply wrinkled, laterally overhanging; mesonotal setae, two, rarely none or three; or prominences low-domed, area oval.

Length, 13.75 to 18.50 mm., average (2), 16.12 mm.; pronotal width, 3.79 to 4.75 mm., average, 4.27 mm.

Female. Length, not recorded. Rostrum with six conical, seta-bearing tubercles, the basal pair set on large, irregular, wrinkled prominences, overhanging in fullness laterad and occupying an oval area. Prolatero-pronotal setae, one left, two right; postlatero-pronotals, two; medio-pronotals, two; mesonotals, two; metanotals, two; setae of eighth tergite, two, small.

Description from preserved wild pupa, specimen 183801.

See full lateral view and caudal view of this female and the caudal view of male of same species, specimen 18389, from same infestation, Pl. I, Figs. 10-12, respectively.

Length, from 13.75 to 18.50 mm.; average (2), 16.12 mm.; pronotal width, 3.79 to 4.75 mm.; average, 4.27 mm.

***Calendra robusta* (Horn).**

Rostrum with six, eight, or ten regular, seta-bearing, conical tubercles, the basal pair set on broad, irregular prominences, high, deeply wrinkled, sides rounded; mesonotal setae usually four or more, sometimes two; medio-pronotal setae, usually two, never more, sometimes wanting; length, 11.65 to 15.63 mm., average (18), 13.52 mm.; pronotal width, 3.11 to 4.64 mm., average, 3.82 mm.

Male. Length, 13.24 mm.; pronotal width, 3.76 mm. Rostrum with nine seta-bearing, conical tubercles, with mark representing the tenth. Basals on strongly raised and wrinkled transverse-oval prominences. Setal lines of the basal, second, and third pairs almost parallel. The fourth pair is very small, situated cephalad-mesad of third pair and about one-fourth the space between setal lines from third pair. The fifth pair is represented on the right by a fair-sized tubercle and seta, on the left by a mere mark, two-thirds of the distance from the

third pair to the apex of the rostrum. Rostrum reaching middle of protibiæ. Prolatero-pronotal setæ, four; postlatero-pronotal setæ, four; medio-pronotals, two; spiraculo-pronotals, four; mesonotals, two left, three right; metanotals, six; setæ on eighth tergite wanting. The apical third of that portion of the rostrum beyond the point of attachment of the antennæ is reduced in diameter. Sides of head with jowls, top of head not uniformly curved. Median rostral line depressed from near basals to near the third pair of tubercles. Rostrum beyond antennæ with transverse rugæ, nearly annulate. The basal prominences are deeply wrinkled, the deepest cleft being transverse, cephalad to the cones. There are about three clefts laterad of each cone.

Description from a pupa which yielded the adult, 26066o.

The pupa of this species is very much like the pupa of *C. aequalis*. There is a marked difference of 4 mm. in average lengths, with an overlap in a few individuals, *aequalis* being the larger. The prominences of the basal rostral tubercles are somewhat higher and narrower in *robusta* than in *aequalis*.

Lengths, from 11.65 to 15.63 mm.; average, (18) 13.52 mm.; pronotal width, 3.11 to 4.64 mm.; average, 3.82 mm.

***Calendra costipennis* (Horn).**

Rostrum with only six seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, high or moderately high, deeply or moderately wrinkled, sides rounded; mesonotal setæ usually four or more, sometimes two; medio-pronotal setæ usually wanting, but may be two or four; length, 9.10 to 14.78 mm., average (43), 11.09 mm.; pronotal width, 2.30 to 4.22 mm., average, 3.27 mm.

Male. Length, 10.50 mm.; pronotal width, 3.53 mm.

Rostrum with six conical, seta-bearing tubercles, the basal pair set upon prominences which are broad, low, and nearly circular. Rostrum reaching fully across the protibiæ. Prolatero-pronotal setæ, one left, none right; postlatero-pronotals, four, of which the outer are very tiny; medio-pronotals, spiraculo-pronotals, and mesonotals, wanting; metanotals, two; setæ of eighth tergite wanting.

Description from reared living pupa, specimen 2409-i.

Lengths, from 9.10 to 14.78 mm.; average (43), 11.09 mm.; pronotal width, 2.30 to 4.22 mm.; average, 3.27 mm.

***Calendra costicollis* var. *callosipennis* (Chttn.).**

Rostrum with only four tubercles, all seta-bearing. Eighth abdominal tergite without large setæ. Setæ of median and spiracular areas of pronotum and setæ of mesonotum usually wanting.

Male. Length, 12.16 mm.; pronotal width, 4.63 mm. Rostrum with four setæ; terminating at caudal margin of protibiæ; area of head in region of caudal margin of compound eyes slightly wrinkled. Prolatero-pronotal setæ, two left, one right; postlatero-pronotals, four;

medio-pronotals, spiraculo-pronotals, mesonotals, and meatanotals wanting; setæ of eighth tergite wanting.

Description from living, reared pupa, specimen 24174d.

Lengths, from 8.76 to 15.95 mm.; average (10), 12.55 mm.; pronotal width, from 2.54 to 6.5 mm.; average (10), 4.13 mm.

Specimen 21173g, a male, is represented by illustrations of full dorsal aspect, side view of head and thorax and of caudal end, showing the greatly reduced armature of setæ of this species, Pl. I, Figs. 13-15.

Calendra maidis (Chtttn.)

Rostrum with six regular, seta-bearing, conical tubercles, with or without additional, promiscuously placed, seta-bearing tubercles, the basal pair set on broad, irregular prominences, high and deeply wrinkled or moderately high and moderately wrinkled; usually four medio-pronotal setæ; mesonotal setæ usually four or more, sometimes two; spiraculo-pronotal setæ usually four, rarely wanting; setæ on eighth tergite very small or wanting; length, 11.11 to 18.00 mm., average (30), 14.05 mm.; pronotal width, 3.44 to 6.45 mm., average, 4.64 mm.

Female. Length, 15.04 mm. Rostrum with six conical, seta-bearing tubercles, the basals set upon broad, irregular prominences, the basal, second, and third pairs normally spaced. Prolatero-pronotal, postlatero-pronotal, medio-pronotal, and spiraculo-pronotal setæ, four each; meso-notals, six; metanotals, four; setæ of eighth tergite wanting.

Description from freshly killed, reared pupa, full lateral and dorsal views illustrated on Pl. II, Figs. 16-17, respectively.

Length, from 11.11 to 18.00 mm.; average (30), 14.05 mm.; pronotal width, 3.44 to 6.45 mm.; average, 4.64 mm.

Calendra cariosa (Oliv.).

Rostrum with only six seta-bearing tubercles, all conical, basal pair set on broad, irregular prominences, moderately high and wrinkled, narrower than in *discolor* and *maidis*, species usually medium or small; prominences not darker than head, base wrinkled, not appearing lobed or granular. Length, 8.31 to 17.00 mm., average (10), 12.49 mm.; pronotal width, 2.66 to 4.40 mm., average, 3.55 mm.

Male. Length, 10.96 mm.; pronotal width, 3.23 mm. Rostrum with six conical, seta-bearing tubercles, the basals without particular prominences; apex reaching beyond protibia, fairly smooth, flattened or concave at apex above. Wing pads without points. Prolatero-pronotal setæ, two tiny, two very tiny; postlatero-pronotals, two small, two tiny; medio-pronotals, two, small; spiraculo-pronotals, tiny; mesonotals, two very tiny; metanotals, two, small; setæ of eighth tergite, two, very short, stout.

Description from live reared pupa, specimen 28136c. See full ventral and lateral illustrations of male *cariosa*, specimen 2028c. Pl. II, Figs. 19a, b, and dorsal and ventral views of ♀, Figs. 18a-b.

Length, from 8.31 to 17.00 mm., average (10), 12.49 mm.; pronotal width, 2.66 to 4.40 mm.; average, 3.55 mm.

***Calendra parvula* (Gyll.).**

Rostrum with only four tubercles, all seta-bearing. Eighth abdominal tergite with one pair of large dorsal setæ as large as largest on ninth tergite. Species small, slender, length from 5.58 mm. to 10.22 mm., pronotal width, from 1.93 to 3.98 mm.; beak appearing long and slender; large setæ of ninth tergite six or eight, usually eight.

Male. Length, 7.09 mm. Rostrum with four seta-bearing tubercles the apical pair slightly caudad to middle of point of attachment of antennæ, the second pair in front of eyes at base of rostrum. Pro-latero-pronotal setæ, four, the outer pair much farther forward than the inner pair; postlatero-pronotal setæ, four, the outer not quite so far forward of the inner as in the prolatero-pronotals; medio-pronotal and spiraculo-pronotal setæ wanting, as also those of the mesonotal and metanotal areas. Two large setæ on eighth tergite. Description from living, reared pupa. Specimen 2340m, preserved. See illustrations of lateral and ventral aspects and dorsum of thorax, Pl. II, Figs. 20-22.

The average length of 73 specimens, of which both the length and the pronotal width were recorded, is 8.47 mm., the average pronotal width, 2.51 mm.

***Calendra minima* (Hart).**

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; outer postlatero-pronotal seta much nearer to inner postlatero-pronotal seta than to either spiraculo-pronotal seta; upper spiraculo-pronotal seta much nearer to lower spiraculo-pronotal than to outer postlatero-pronotal seta; length, 6.46 to 8.69 mm., average (15), 7.50 mm.; pronotal width, 1.85 to 2.50 mm., average, 2.15 mm.

Female. Length, 7.87 mm., pronotal width, 2.21 mm. Rostrum with six seta-bearing, conical tubercles, no basal prominences; basal setæ about half the length of second setæ. The head merges into the rostrum gradually, giving it a particularly massive appearance. Apex of rostrum reaching past the middle of the protibiae. Prolatero-pronotal and postlatero-pronotal setæ, each four; medio-pronotal setæ, two; spiraculo-pronotal setæ, four; mesonotal setæ, two; metanotal setæ, four; setæ of eighth tergite, two, one as large as largest on ninth tergite, the other less than half the size; setæ of seventh tergite high-crested. All pronotal setæ are coarse and all are visible from the dorsal view, giving the species a very spiny appearance, conspicuously more so than that of *parvula*.

Description from wild pupa which yielded an adult *minima*, specimen 26049u. See illustrations of side view and view of caudal end of female *minima*, specimen 23721a, Pl. II, Figs. 23-24.

Length, from 6.46 to 8.69 mm.; average (15), 7.50 mm.; pronotal width, 1.85 to 2.50 mm.; average, 2.15 mm.

***Calendra retusa* (Gyll.)**

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; mesonotal and metanotal setæ, one or more pairs each; setæ of eighth tergite, two large, dorsal, rarely irregular, no small setæ; length, 8.90 to 11.00 mm., average (10), 10.04 mm.; pronotal width, 2.75 to 3.42 mm., average, 3.05 mm.

Female. Length not recorded. Rostrum with six conical, seta-bearing tubercles, without basal prominences. Prolatero-pronotal and postlatero-pronotal setæ, four each; medio-pronotal setæ, one left, two right; spiraculo-pronotal setæ, four; mesonotal and metanotal setæ, each two; setæ of eighth tergite, two, large.

Description from freshly killed, reared pupa, specimen 23731ar. See full dorsal and ventral illustrations, showing the setal armature of the species, Pl. II, Figs. 25, 26.

Length, from 8.90 to 11.00 mm.; average (10), 10.04 mm.; pronotal width, 2.75 to 3.42 mm.; average, 3.05 mm.

***Calendra destructor* (Chhtn.).**

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; mesonotal and metanotal setæ each one or more pairs; setæ of eighth tergite, one large dorsal pair, usually one or two pairs of small setæ; length, 8.05 to 10.84 mm., average (10), 9.46 mm.; pronotal width, 3.00 to 4.65 mm., average, 3.97 mm.

Female. Length not recorded. Rostrum with six conical, seta-bearing tubercles, none on prominences. Spaces between setæ, transversely and longitudinally, about twice the length of the setæ. Prolatero-pronotal and postlatero-pronotal setæ, four each; medio-pronotal setæ, two; spiraculo-pronotal setæ, four; mesonotal and metanotal setæ, each two; setæ of eighth tergite, eight, two large, dorsal, six small.

Description from living, reared pupa, specimen 23188j. See full dorsal, lateral, and ventral illustrations and illustration of last four segments of abdomen, caudo-ventral view, showing setæ of seventh, eighth, and ninth tergites, Pl. III, Figs. 27, 28, 29, 30, respectively.

Length, from 8.05 to 10.84 mm.; average (10), 9.46 mm.; pronotal width, 3.00 to 4.65 mm.; average, 3.97 mm.

***Calendra zeæ* (Walsh).**

Rostrum with only four tubercles, each seta-bearing; eighth abdominal tergite without large setæ; medio-pronotal, spiraculo-pronotal, and mesonotal setæ not all wanting; species small, 12 mm. or less.

Female. Length, 11.44 mm.; pronotal width, 3.20 mm. Rostrum with four conical tubercles, each seta-bearing. Prolatero-pronotal setæ, four, small, one very tiny; postlatero-pronotals, four, rather short, coarse, fairly approximate; medio-pronotals wanting; spiraculo-pronotals, four, very small, nearer each other than either to spiracle; mesonotals wanting; metanotals, four; setæ of eighth tergite wanting.

Description from living, reared pupa, specimen 25087d.

Length, from 6.69 to 11.60 mm.; average (14), 9.41 mm.; pronotal width, 2.11 to 3.59 mm.; average, 2.97 mm.

One specimen of this species showed an absence of one of the regular rostral setæ on one side and the development of one cephalad of the regular series, indicating a tendency to instability in the setal characters of the rostrum in this species.

Calendra scoparia (Horn).

Rostrum with only four tubercles, all seta-bearing; eighth abdominal tergite without large setæ; medio-pronotal, spiraculo-pronotal, and mesonotal setæ not all wanting; species large, 14 mm. or longer, or rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; mesonotal setæ wanting; average size, larger than *venatus*.

Female. Length not recorded. Rostrum with four setæ; prolatero-pronotal setæ, four, nearly central in their respective cephalic quarters; postlatero-pronotals, four; medio-pronotals wanting; spiraculo-pronotals, four, one near each spiracle, the other, very small, two-thirds of the way up from the spiracle to the postlatero-pronotals; mesonotals wanting; metanotals, two normal, two very tiny; setæ of eighth tergite wanting.

Description from living, reared pupa, specimen 23112a. See dorsal and ventral aspects of full-length pupa and side of caudal end, illustrating arrangement or absence of setæ, Pl. III, Figs. 31-33.

Length, from 11.86 to 15.37 mm.; average (13), 13.65 mm.; pronotal width, 3.50 to 4.71 mm.; average, 4.04 mm.

Calendra callosa (Oliv.)

Rostrum with six regular tubercles, all or only the cephalad four bearing setæ; all conical, the basals set on three-lobed or granular bases, usually darker than the head, sometimes on broad, irregular prominences, moderately high and wrinkled, narrower than in *discolor* and *maidis*. Species usually medium or small, rarely more than 13 mm. long.

Female. Length not recorded. Rostrum with four conical, seta-bearing tubercles cephalad of the basal, non-seta-bearing, prominent granular tubercles, darker than the head. Prolatero-pronotal setæ, four; postlatero-pronotals, four; medio-pronotals, spiraculo-pronotals, and mesonotals, wanting; metanotals, two; setæ of eighth tergite wanting.

Description from wild alcoholic pupa, specimen 18347f. See illustrations of this specimen, showing full dorsal and ventral surfaces, with face and notal characters, Pl. III, Figs. 34, 35. See also the illustration of male pupa 23700s, ventral view, Pl. III, Fig. 36.

Length, from 8.17 to 12.83 mm.; average (40), 10.35 mm.; pronotal width, 2.51 to 4.50 mm.; average, 3.27 mm.

Calendra melanocephala (Fab.).

Rostrum with six regular tubercles, only the cephalad four bearing setæ; basal pair of tubercles tall-rosetted, excrescence-like; medio-pronotal setæ wanting; basal rostral tubercles large; space between these usually less than half the diameter of either.

Female. Length not recorded. Rostrum with six tubercles, the basal pair tall-rosetted, without setæ; four cephalad tubercles simple cones, each seta-bearing. Prolatero-pronotal not recorded; postlatero-pronotals, four; medio-pronotals wanting; spiraculo-pronotals, one tiny seta observed on right edge of disc, others not found; mesonotals wanting; metanotals, one found on right side; setæ of eighth tergite wanting.

Description from wild pupa, specimen 18252a. See illustration of entire ventral aspect, especially portraying the rostral tubercles and setæ, Pl. III, Fig. 37. Also, see illustration of thorax, showing paucity of notal setæ, and illustration of caudal end of body, ventral view, and entire lateral and ventral views, all of specimen 20111i, a male, Pl. III, Figs. 38, 39, 40, 41.

Length, from 10.27 to 10.35 mm.; average, 10.31 mm.; pronotal width, 4.29 to 4.53 mm.; average (2), 4.41 mm.

In other specimens, the prolatero-pronotal setæ were sometimes wanting, some had one, some had two, and one had three.

Calendra pontederiæ (Chttn.).

Rostrum with six regular tubercles, only the cephalad four bearing setæ; basal tubercles tall-rosetted, excrescence-like; medio-pronotal setæ present.

Female. Length not recorded. Rostrum with six tubercles, the basal pair tall-rosetted, without setæ; four cephalad tubercles simple cones, each seta-bearing. Prolatero-pronotal setæ, four; postlatero-pronotals, four; medio-pronotals, two; spiraculo-pronotals, four; mesonotal and metanotal setæ wanting; two large, distinctly capitate setæ and four small setæ on eighth tergite. The spiraculo-pronotal setæ are very tiny, just below the edge of the pronotal disc.

Description from preserved, reared pupa, specimen 22177p.

Calendra venatus (Say).

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; mesonotal setæ present or wanting; setæ of eighth tergite present; metanotal setæ, one or more pairs; length, 9.22 to 12.75 mm., average, (68), 10.81 mm., pronotal width, 2.32 to 3.79 mm., average, 3.05 mm.

Female. Length not recorded. Rostrum with six conical seta-bearing tubercles, without basal prominences. Prolatero-pronotal and postlatero-pronotal setæ, four each; medio-pronotal setæ, two; spiraculo-

pronotal, mesonotal, and metanotal setæ, four each; setæ of eighth tergite, two large and two small setæ.

Description from preserved reared pupa, specimen 23128h. See full dorsal and lateral illustrations of this species, Pl. III, Figs. 42-43.

Length, from 9.22 to 12.75 mm.; average (68), 10.81 mm.; pronotal width, 2.32 to 3.79 mm.; average, 3.05 mm.

***Calendra phoeniciensis* (Chtttn.).**

Rostrum with only four tubercles, all seta-bearing. Eighth abdominal tergite with one pair of large dorsal setæ as large as largest on ninth tergite. Species small, slightly more robust than *parvula*; length, from 7.89 to 9.02 mm., pronotal width, from 2.43 to 3.46 mm.; beak appearing stocky; large setæ of ninth tergite four to six, usually six.

Female. Length, 9.45 mm.; pronotal width, 2.62 mm. Rostrum with four conical tubercles, each seta-bearing; stocky, yet reaching beyond middle of front tibiæ; sculptured by about eighteen distinct and six faint rings between setæ and apex; apex concave above, in median line, the depression interrupting the transverse rings. Pro-latero-pronotal setæ, one, normal, and one, half length; postlatero-pronotals, two; medio-pronotals, mesonotals, and metanotals wanting; seventh tergite, five; eighth, two, large; ninth, six.

Description from living, reared pupa, specimen 28005h.

The pro-latero-pronotal setæ of this species are usually two pairs, one pair of normal size, the other of very minute setæ. The rostrum frequently shows a rippled surface at its base, about the region of the posterior ends of the compound eyes.

***Calendra incongrua* (Chtttn.).**

Rostrum with six regular tubercles, only the cephalad four bearing setæ; basal pair of tubercles tall-rosetted, excrescence-like; medio-pronotal setæ absent; basal rostral tubercles smaller than in *melanocephala*; space between these usually more than half the diameter of either.

Female. Length, 11.29 mm.; pronotal width, 2.86 mm. Rostrum with basal tubercles tall-rosetted, without setæ, darker than rest of head, about three-fifths of the diameter of the tubercle between them; four anterior tubercles conical, seta-bearing. Setal lines diverging slightly apically. Rostrum extending beyond the protibiæ. Pro-latero-pronotal setæ, four; postlatero-pronotal setæ, four; medio-pronotals, spiraculo-pronotals, mesonotals, metanotals, and setæ of eighth tergite, wanting.

Description from pupa 26060a which yielded an adult. The post-latero-pronotal setæ are almost always all present, the pro-latero-pronotals are wanting in about seven per cent. The rostral tubercles and setæ are almost perfectly constant. One specimen had a supernumerary tubercle with seta. The space between the basal tubercles

varies from less than half to more than three-quarters of the diameter of either between them, though usually they are more than half the diameter apart.

Length, from 7.00 to 12.07 mm.; average (106), 10.23 mm.; pronotal width, 2.02 to 3.91 mm.; average, 2.65 mm.

Calendra oblita (Lec.).

Rostrum with six seta-bearing tubercles only, basal pair not on broad, irregular prominences; outer postlatero-pronotal seta much nearer to upper spiraculo-pronotal seta than to inner postlatero-pronotal seta. Upper spiraculo-pronotal seta much nearer to outer postlatero-pronotal seta than to lower spiraculo-pronotal seta. Length, 7.30 to 10.53 mm., average (15), 8.89 mm.; pronotal width, 2.24 to 3.37 mm., average, 2.80 mm.

Male. Length, 8.35 mm.; pronotal width, 2.90 mm. Rostrum with six conical, seta-bearing tubercles, without any basal prominence; basal tubercles nearly transverse; space between basal and second tubercles two-thirds as great as space between second and third tubercles. Prolatero-pronotal setæ, four; postlatero-pronotal setæ, four, the outer much nearer to upper spiraculo-pronotal setæ than to inner; medio-pronotal setæ, two; spiraculo-pronotal setæ, four, the upper much nearer to outer postlatero-pronotal setæ than to lower, *i. e.*, the upper spiraculo-pronotal seta is twice as far from the lower spiraculo-pronotal as from the outer postlatero-pronotal seta, and the space between the inner and outer postlatero-pronotal setæ is one and one-half times the space between the outer postlatero-pronotal and the upper spiraculo-pronotal setæ; mesonotal setæ, six, one on each side, being in front of base of elytra; metanotal setæ, four left, three right; setæ of eighth tergite, two large. Head non-symmetrical, wrinkled.

Description from living reared pupa, specimen 25102a.

Length, from 7.30 to 10.53 mm., average (15), 8.89 mm.; pronotal width, 2.24 to 3.37 mm., average, 2.80 mm.

KEY.

- a. Rostrum with only four seta-bearing tubercles, or if more, the additional setae obviously not of standard series.
- b. Rostrum with only four tubercles, or, if more, "sports."
- c. Eighth abdominal tergite with one pair of large dorsal setae as large as largest on ninth tergite. Species small, not exceeding 10 mm. in length.
 - d. Slender, widths of pronotum about 2.51 mm.; average total length about 8.47 mm.; beak appearing long and slender; large setae of ninth tergite six or eight, usually eight. Develops in corn prop-roots, *Panicum repens*, *P. agrostoides*, timothy, *Agrostis alba*, orchard grass, bluegrass, wheat, barley, rye, *Agropyron repens*, *Elymus canadensis*, *E. robustus*, *Sitanion elymoides*, *Cyperus esculentus*, *C. strigosus*, *C. echinatus*. Occurs in Ala., Ark., Conn., D. C., Fla., Ga., Ill., Ind., Ia., Kans., Ky., Md., Mass., Mich., Minn., Miss., Mo., Neb., N. H., N. J., N. Y., N. C., O., Okla., Pa., R. I., S. C., S. D., Tex., Va., Wis. ***Calendra parvula***
 - dd. Slightly more robust, average width of pronotum (18), 2.81 mm., average total length (18), 9.02 mm.; beak appearing stocky; large setae of ninth tergite four or six, usually six. Develops in Johnson grass, oats, Bermuda grass, wheat, and barley. Occurs in Ariz. ***C. phoeniciensis***
- cc. Eighth abdominal tergite without large setae.
 - e. Setae of median and spiracular areas of pronotum and setae of mesonotum usually wanting. Develops in *Rynchospora corniculata*, *Carex crus-corvi*, *C. riparia*, *C. lupuliformis*, *C. lupulina* var. *pedunculata*, and *C. vesicaria* (?). Occurs in Ala., Ark., Ill., Kans., La., Mo. ***C. costicollis* var. *callosipennis***
 - ee. Setae of these areas not all wanting.
 - f. Species large, more than 11.75 mm. long. Develops in *Spartina michauxiana*, *Cyperus rotundus*, *Scirpus atrovirens*, *Carex riparia*, and *C. vesicaria* (?). Occurs in Ala., Ark., Md., Ill., Ia., Kans., Mo., Neb., and Wis. ***C. scoparia***
 - ff. Species small, less than 11.75 mm. long. Develops in timothy and bluegrass. Occurs in Ala., Calif., Conn., Del., Fla., Ill., Ind., Ia., Kans., Ky., Md., Mass., Mich., Minn., Miss., Mo., Neb., N. H., N. J., N. Y., N. C., O., Pa., R. I., S. C., Tex., Va., Wis., and Que. ***C. zeae***
- bb. Rostrum with two tubercles caudad of the four seta-bearing tubercles.
 - g. Rostrum with basal pair of tubercles tall-rosetted, excrescence-like.
 - h. Medio-pronotal setae present. Develops in *Pontederia cordata*. Occurs in Ala., Fla., Ill., La., Md., Mass., Mich., Mo., N. J., R. I., S. C., and Tex. ***C. pontederiae***
 - hh. Medio-pronotal setae absent.
 - i. Basal rostral tubercles large; space between these usually less than half the diameter of either. Develops in *Leersia oryzoides*. Occurs in Conn., D. C., Ill., Ind., Ia., Kans., Md., Mass., Mich., Minn., Mo., Neb., N. H., N. J., N. Y., O., Pa., Va., W. Va., Wis. and Ont. ***C. melanocephala***
 - ii. Basal tubercles smaller, space between usually more than half the diameter of either. Develops in *Scirpus validus*. Occurs in Ill., Ia., Kans., Md., and Wis. ***C. incongrua***
 - gg. Rostrum with basal pair or tubercles otherwise than above.

- j. Basal pair of tubercles resembling the forward pairs. Develops in *Typha latifolia* and *Sparganium eurycarpum*. Occurs in Ala., Ariz., Calif., Col., Del., Fla., Id., Ill., Ind., Ia., Kans., La., Md., Mass., Mich., Minn., Miss., Mo., Neb., N. J., N. Y., O., Pa., S. D., Tex., Ut., Wis., Wyo., Ont. and Cuba..... **C. pertinax**
- jj. Basal pair of tubercles not resembling the forward tubercles.
 - k. Basal pair of tubercles with three-lobed or granular bases, usually darker than rest of head; species medium or small, usually less than 13 mm. long. Develops in corn, *Panicum clandestinum*, wheat, *Cyperus schweinitzii*, *C. pseudovegetus*, *C. rotundus*, *C. esculentus*, *C. erythrorhizos*, *C. ferax*, *C. strigosus*, *C. ovularis*, *Rhynchospora corniculata*, *Carex riparia*, *C. lupuliformis*, and *Juncus torreyi*. Occurs in Ala., Ariz., Ark., Fla., Ga., Ill., Ind., Ia., Kans., La., Md., Mich., Minn., Miss., Mo., Neb., N. J., N. M., N. C., Okla., Pa., S. C., Tex., and Va..... **C. callosa**
 - kk. Basal tubercles scarcely recognizable as such, and on a rippled, elevated contour of the head, or appearing as a cluster of miniature tubercles; size large, usually more than 13 mm. long. (See notes under "j.")..... **C. pertinax**
- aa. Rostrum with six or more seta-bearing tubercles.
 - 1. Rostrum with more than six seta-bearing tubercles.
 - m. Seta-bearing tubercles in excess of standard six, two or four, appropriately spaced for regular series, sometimes with additional seta-bearing tubercles promiscuously placed. Two medio-pronotal setae usually present.
 - n. Medio-pronotals two, merged with prolatero-pronotals. Length, 11.66 to 19 mm., average (8), 17.26 mm. Develops in *Scirpus validus*. Occurs in Cal. and Ore..... **C. discolor**
 - nn. Medio-pronotals two, in normal position. Length, 11.65 mm. to 15.63 mm., average (18), 13.52 mm. Develops in *Scirpus validus*. Occurs in Col., Ill., Ind., Ia., Kans., Mich., Minn., Mo., Neb., N. J., O., Ut., Wash., and Wis..... **C. robusta**
 - mm. Seta-bearing tubercles in excess of standard six, one to ten, promiscuously placed.
 - o. Usually four medio-pronotal setae; length, 11.11 to 18 mm., average (30), 14.05 mm. Develops in corn and *Tripsacum dactyloides*. Occurs in Ala., Kans., La., Mass. (?), Mich. (?), Okla., S. C., Tex., and Wash. (?)..... **C. maidis**
 - oo. Two large medio-pronotal setae; spiraculo-pronotal setae, two large and one small on each side; all setae barbed; length, 7.81 to 8.25 mm., average (2), 8.03 mm.; pronotal width, 2.78 to 2.98 mm., average, 2.88 mm. Develops in Bermuda grass. Occurs in Ala., Fla., Md., Minn., N. J., N. Y., Pa., and S. C..... **C. inaequalis**
 - II. Rostrum with six seta-bearing tubercles only.
 - p. Rostral tubercles all conical, basal pair set on broad, irregular prominences.
 - q. Prominences high, deeply wrinkled.
 - r. Sides of prominences rounded; mesonotal setae usually four or more, sometimes two.
 - s. Medio-pronotal usually four, spiraculo-pronotal setae usually four, rarely wanting. (See notes under "o.")..... **C. maidis**
 - ss. Medio-pronotal setae rarely more than two, occasionally wanting.
 - t. Medio-pronotal setae never more than two, occasionally wanting.
 - u. Length, 14.77 to 23 mm., average (12) 18.49 mm.; pronotal width, 4.36 to 6.49 mm., average, 5.73 mm. Develops in *Scirpus validus* and *S. fluvialis*. Occurs in Ala., Cal., Col., Conn., D. C., Fla., Ill., Ind., Ia., Kans., Ky., La., Mich., Minn., Mo., Neb., N. J., N. Y., N. D., O., Okla., Pa., S. D., Tex., Va., Wash., Wis., Ont., and Alberta..... **C. aequalis**

- uu. Length, 11.65 to 15.63 mm., average (18), 13.52 mm.; pronotal width, 3.11 to 4.64 mm., average, 3.82 mm. (See notes under "nn.") *C. robusta*
- tt. Medio-pronotal setae usually wanting, but may be two or four; length, 9.10 to 14.78 mm., average (43), 11.09 mm.; pronotal width, 2.30 to 4.22 mm., average, 3.27 mm. Develops in *Scirpus validus* and *Carex comosa*. Occurs in Calif., Col., Conn., D. C., Ida., Ill., Ind., Ia., Kans., Ky., La., Me., Mass., Mich., Minn., Miss., Mo., Neb., N. H., N. J., N. Y., N. C., N. D., O., Pa., S. C., S. D., Ut., Wis., Ont., Alberta, Man., and B. C. *C. costipennis*
- rr. Prominences overhanging laterad.
 - v. Mesonotal setae two, rarely none or three; prominences of basal tubercles low-domed, areas oval.
 - w. Length, 13.75 to 18.50 mm., average (2), 16.12 mm.; pronotal width, 3.79 to 4.75 mm., average, 4.27 mm. Develops in *Zizaniopsis miliacea*. Occurs in Ala., Fla., La., Miss., Mo., and Tex. *C. ludoviciana*
 - ww. Length, 8.31 to 17 mm., average (10) 12.49 mm.; pronotal width, 2.66 to 4.40 mm., average, 3.55 mm. Develops in *Cyperus pseudo-vegetus*, *C. rotundus*, *C. esculentus*, *C. erythrorhizos*, *C. ferax*, *C. strigosus*, *Scirpus validus*, *S. atrovirens*, *S. eriophorum*, and *Rynchospora corniculata*. Occurs in Ala., Conn., Fla., Ill., Kans., La., Mass., Mich., Miss., Mo., Neb., N. J., N. Y., N. C., O., Pa., S. C., and Tex. *C. cariosa*
- vv. Mesonotal setae four; basal tubercles in their entirety appearing as hemispheres cut under at outer edge or circular with high vertical boundaries. Develops in *Spartina cynosuroides*, chiefly below high tide. Occurs in Conn., Fla., Md., Mass., N. J., N. Y., and R. I. *C. setiger*
- q. Prominences of basal tubercles moderately high, moderately wrinkled.
 - x. Prominences broad.
 - y. Species small, less than 12 mm. in average length.
 - z. Length, 9.10 to 14.78 mm., average (43), 11.09 mm.; pronotal width, 2.30 to 4.22 mm., average, 3.27 mm. (See notes under "tt.") *C. costipennis*
 - zz. Length, 7.81 to 8.25 mm., average (2), 8.03 mm.; pronotal width, 2.78 to 2.98 mm., average, 2.88 mm. (See notes under "oo.") *C. inaequalis*
 - yy. Species large, more than 12 mm. in average length.
 - a'. Two or more setae on eighth abdominal tergite; no spiraculo-pronotal and never more than two medio-pronotal setae. (See notes under "n.") *C. discolor*
 - aa'. Setae on eighth tergite very small or wanting; four medio-pronotal and four spiraculo-pronotal setae usually present. (See notes under "o.") *C. maidis*
 - xx. Prominences relatively narrow; species usually medium or small, rarely more than 13 mm. long.
 - b'. Prominences darker than head, three-lobed or granular. (See notes under "k.") *C. callosa*
 - bb'. Prominences not darker than rest of head; base wrinkled, not appearing lobed or granular. (See notes under "ww.") *C. cariosa*
- pp. Rostral tubercles conical, basal pair not on broad, irregular prominences.
 - c'. Pupae less than 9.25 mm. long.
 - d'. Outer postlatero-pronotal seta much nearer to upper spiraculo-pronotal seta than to inner postlatero-pronotal seta. Upper spiraculo-pronotal seta much nearer to outer postlatero-pronotal seta than to lower spiraculo-pronotal seta. Develops in timothy. Occurs in Ariz., Kans., La., Md., Mich., Miss., N. M., N. C., Tex., and Wis. *C. oblita*

- dd'. Outer postlatero-pronotal seta much nearer to inner postlatero-pronotal seta than to either spiraculo-pronotal seta. Upper spiraculo-pronotal seta much nearer to lower than to either postlatero-pronotal seta. Develops in *Typha latifolia*, rice, *Leersia oryzoides*, timothy, *Agrostis alba*, orchard grass, *Glyceria nervata*, wheat, *Agropyron repens*, *Elymus virginicus*, *E. canadensis* (?), *E. striatus*, and *Hystrix patula*. Occurs in Ala., Ark., Fla., Ill., Ind., Ia., Kans., Ky., La., Md., Mass., Mich., Mo., Neb., N. J., N. Y., O., Pa., S. C., and Va. *C. minima*
- cc'. Pupae 9.25 mm. long or longer.
- e'. Mesonotal setae wanting.
- f'. Total length, 11.86 to 15.37 mm., average (13), 13.65 mm.; pronotal width, 3.50 to 4.71 mm., average, 4.04 mm. (See notes under "f.")..... *C. scoparia*
- ff'. Total length, 9.22 to 12.75 mm., average (68), 10.81 mm.; pronotal width, 2.32 to 3.79 mm., average, 3.05 mm. Develops in timothy, Bermuda grass, wheat, *Cyperus esculentus* and *Scirpus validus*. Occurs in Ala., Ariz., Ark., Calif., Col., Conn., Del., Fla., Ga., Ill., Ind., Ia., Kans., Ky., La., Md., Mass., Mich., Minn., Miss., Mo., Mont., Neb., N. H., N. J., N. Y., N. C., O., Okla., Ore., Pa., R. I., S. C., Tex., Va., Wis., Wyo., and Ont. *C. venatus*
- ce'. Mesonotal setae present.
- g'. Setae of the eighth tergite wanting. (See notes under "u.")..... *C. aequalis*
- gg'. Setae of eighth tergite present; mesonotal and metanotal setae each one or more pairs.
- h'. Setae visible on eighth tergite, one pair large, dorsal, rarely irregular; no small setae. Develops in *Panicum repens*. Occurs in Ala., Fla., Mass., N. J., N. Y., N. C., Pa., and S. C. *C. retusa*
- hh'. Setae visible on eighth tergite, two or more pairs, rarely less, one pair being large, dorsal.
- i'. Mesonotal and metanotal setae two each, rarely more. Develops in timothy, wheat, *Cyperus esculentus*, *Juncus torreyi* and *J. acuminatus*. Occurs in Ala., Ark., Ill., Ind., Ia., Kans., Md., Mich., Miss., Mo., Neb., N. J., Okla., Pa., S. C., Tex., and Can. *C. destructor*
- ii'. Mesonotal and metanotal setae four or six each, usually four, very rarely two, each. (See notes under "ff'."),
C. venatus

CALENDRA-PROGENY HOST-PLANT LIST.

The plants included in this list are those species from which *Calendra* eggs, larvæ, pupæ, and new adults within the pupa cell have been collected, either within the tissue of the plant or in such close approximation to the definite larval excavation and exit hole as to leave no uncertainty as to the correctness of the relationship of the insect and its host plant.

Many collections were made in plants too immature or too old to permit of satisfactory determination. In some cases, return trips have been made to points of collection and determinable stages of growth of the plant then believed to be the same species and the same stand as that from which the collection was made, have been collected. Sometimes, the process of examining the plants for contained immature stages automatically destroyed the plant for determination.

Determinations have been secured generally from well qualified botanists, frequently after the writer has made a provisional determination, in his effort to know the billbug host plants in the field. Errors that may appear in determinations of host plants, if any appear, will be chiefly the error of the writer in discriminating between the host plant and similar plants in close proximity in the field.

The species of *Calendra* are given according to the Catalogue of Coleoptera of America, North of Mexico, by Leng.

GROUP A.

Calendra inaequalis, Uneven Billbug.

Cynodon dactylon, Bermuda Grass.

GROUP B.

Calendra aequalis, Clay-colored Billbug.

Zea mays, Corn. *Scirpus validus*, Am. Great Bulrush; Mat-rush; Tule. **Scirpus fluviatilis*, River Bulrush.

Calendra discolor, Tule Billbug.

Scirpus validus.

*Those plants marked with the asterisk are, in each case, the preeminent host plants for the particular billbug under consideration, in the opinion of the writer.

GROUP C.

Calendra pertinax, Cat-tail Billbug.

**Typha latifolia*, Common Cat-tail, Broad-leafed Cat-tail. *Sparanium eurycarpum*, Broad-fruited Bur-reed.

Calendra setiger, Low-tide Billbug.

**Spartina cynosuroides*, Salt Reed-grass.

Calendra ludoviciana, Knife-flag Billbug.

**Zizaniopsis miliacea*, Knife-flag, Zizaniopsis.

Calendra robusta, Robust Billbug.

**Scirpus validus*.

Calendra costipennis, Rib-winged Billbug.

**Scirpus validus*. *Carex comosa*, Bristly Sedge.

Calendra costicollis v **callosipennis**, Lake-bank Sedge Billbug.

Rhynchospora corniculata, Beaked Rush. *Carex crus-corvi*, Raven's-foot Sedge. **Carex riparia*, Lake-bank Sedge. *Carex lupuliformis*, Hop-like Sedge. *Carex lupulina*, v. *pedunculata*, Hop Sedge. *Carex vesicaria*, Inflated Sedge, (?).

Calendra maidis, Maize Billbug.

Zea mays, Corn. **Tripsacum dactyloides*, Gama or Sesame Grass.

Calendra cariosa, Beaked-rush Billbug.

Cyperus pseudovegetus, Marsh Cyperus. *Cyperus rotundus*, Nut-grass, Coco-grass. *Cyperus esculentus*, Yellow Nut-grass, (?). *Cyperus erythrorhizos*, Red-rooted Cyperus. *Cyperus ferox*, Coarse Cyperus. *Cyperus strigosus*, Straw-colored Cyperus. *Scirpus validus*. *Scirpus atrovirens*, Dark-green Bulrush. *Scirpus eriophorum*, Wool-grass. **Rhynchospora corniculata*, Beaked Rush.

GROUP D.

Calendra parvula, Bluegrass Billbug.

Zea mays, Corn (Prop-roots). *Panicum repens*, Creeping Panic. *Panicum agrostoides*, Red-top Panic. *Phleum pratense*, Timothy. *Agrostis alba*, Fiorin; White Bent-grass; Red-top. *Dactylus glomeratus*, Orchard Grass. **Poa pratensis*, Kentucky Bluegrass. *Triticum sativum*, Wheat. *Agropyron repens*, Couch-grass; Quitch-grass; Quack Grass. *Hordeum sativum*, Barley. *Hordeum jubatum*, Squirrel-tail Grass. *Secale cereale*, Rye. *Elymus canadensis*, Nodding Wild Rye; Canadian Lyme-grass. *Elymus robustus*, Robust Wild Rye. *Sitanion elymoides*, Long-bristled Wild Rye. *Cyperus esculentus*. *Cyperus strigosus*. *Cyperus echinatus*, Echinate Sedge.

Calendra minima, Terrell-grass Billbug.

Typha latifolia. *Oryza sativa*, Rice. *Leersia oryzoides*, Rice Cut-grass. *Phleum pratense*, Timothy. **Agrostis alba*. *Dactylus glomeratus*. *Glyceria nervata*, Meadow Grass; Nerved Manna-grass. *Triticum sativum*, Wheat. *Agropyron repens*. **Elymus virginicus*, Terrell-grass; Virginia Wild Rye. *Elymus canadensis*, (?) *Elymus striatus*, Slender Wild Rye. *Hystrix patula*, Bottle-brush Grass.

Calendra retusa, Creeping Panic Billbug.

**Panicum repens*.

Calendra destructor, Destructive Billbug

Phleum pratense. *Triticum sativum*. **Cyperus esculentus*. *Juncus torreyi*, Torrey's Rush. *Juncus acuminatus*, Sharp-fruited Rush.

Calendra zeæ, Timothy Billbug.

**Phleum pratense*. *Poa pratensis*.

Calendra scoparia, Tall Marsh-grass Billbug.

Spartina michauxiana, Tall Marsh Grass. *Cyperus rotundus*, (?) *Scirpus atrovirens*. **Carex riparia*. *Carex vesicaria*, (?)

Calendra callosa, Curlew Billbug

Zea mays, Corn. *Panicum clandestinum*, Corn Grass; Deer-tongue Grass. *Triticum sativum*. *Cyperus schweinitzii*, Schweinitz's Cyperus. *Cyperus pseudovegetus*. *Cyperus rotundus*. **Cyperus esculentus*. *Cyperus erythrorhizos*. *Cyperus ferax*. *Cyperus strigosus*. *Cyperus ovalaris*, Globose Cyperus. *Rhynchospora corniculata*. *Carex riparia*. *Carex lupuliformis*. *Juncus torreyi*.

Calendra melanocephala, Cut-grass Billbug.

**Leersia oryzoides*.

Calendra pontederiæ, Pickerel-weed Billbug

**Pontederia cordata*, Pickerel-weed.

Calendra venatus, Hunting Billbug.

Phleum pratense. *Cynodon dactylon*. *Triticum sativum*. **Cyperus esculentus*. *Scirpus validus*.

Calendra phoeniciensis, Phoenix Billbug.

Sorghum halipense, Johnson Grass. *Avena sativa*, Oats. **Cynodon dactylon*. *Triticum sativum*. *Hordeum sativum*.

Calendra incongrua, Incongruous Billbug.

**Scirpus validus*.

Calendra oblita, Oblite Billbug.

Phleum pratense.

HOST-PLANT CALENDRA-PROGENY LIST.

TYPHACEÆ (Cat-tail Family).

Typha latifolia, Common Cat-tail.

Calendra pertinax, Cat-tail Billbug. *Calendra minima*, Terrell-grass Billbug.

SPARGANIACEÆ (Bur-Reed Family).

Sparganium eurycarpum, Broad-fruited Bur-reed.

Calendra pertinax.

GRAMINEÆ (Grass Family).

Zea mays, Corn.

Calendra aequalis, Clay-colored Billbug. *Calendra callosa*, Curlew Billbug. *Calendra maidis*, Maize Billbug. In Corn Prop-roots: *Calendra parvula*, Bluegrass Billbug.

Tripsacum dactyloides, Gama or Sesame Grass.

Calendra maidis.

Sorghum halepense, Johnson Grass.

Calendra phoeniciensis, Phoenix Billbug.

Panicum repens, Creeping Panic.

Calendra retusa, Creeping Panic Billbug. *Calendra parvula*.

Panicum agrostoides, Munro Grass.

Calendra parvula.

Panicum clandestinum, Corn Grass; Deer-tongue Grass.

Calendra callosa.

Oryza sativa, Rice.

Calendra minima.

Zizaniopsis miliacea, Knife-flag; Zizaniopsis.

Calendra ludoviciana, Knife-flag Billbug.

Leersia oryzoides, Rice Cut-grass.

Calendra melanocephala, Cut-grass Billbug. *Calendra minima*.

Phleum pratense, Timothy.

Calendra destructor, Destructive Billbug. *Calendra minima*. *Calendra oblita*, Oblite Billbug. *Calendra parvula*. *Calendra venatus*, Hunting Billbug. *Calendra zeae*, Timothy Billbug.

Agrostis alba, Fiorin; White Bent-grass; Red-top.

Calendra parvula. *Calendra minima*.

Avena sativa, Oats.

Calendra phoeniciensis.

Spartina michauxiana, Tall Marsh Grass.

Calendra scoparia, Tall Marsh Grass Billbug.

Spartina cynosuroides, Salt Reed-grass.

Calendra setiger, Low-tide Billbug.

Cynodon dactylon, Bermuda Grass.

Calendra inequalis, Uneven Billbug. *Calendra phoeniciensis*.

Calendra venatus.

Dactylus glomeratus, Orchard Grass.

Calendra parvula. *Calendra minima*.

Poa pratensis, Kentucky Bluegrass.

Calendra parvula. *Calendra zeae*.

Glyceria nervata, Meadow Grass; Nerved Manna Grass.

Calendra minima.

Triticum sativum, Wheat.

Calendra parvula. *Calendra minima*. *Calendra destructor*. *Calendra callosa*. *Calendra venatus*. *Calendra phoeniciensis*.

Agropyron repens, Couch Grass; Quitch Grass; Quack Grass.

Calendra parvula. *Calendra minima*.

Hordeum sativum, Barley.

Calendra parvula. *Calendra phoeniciensis*.

Hordeum jubatum, Squirrel-tail Grass.

Calendra parvula.

Secale cereale, Rye.

Calendra parvula.

Elymus virginicus, Terrell Grass; Virginia Wild Rye.

Calendra minima

Elymus canadensis, Nodding Wild Rye, Canada Lyme-grass.

Calendra parvula. *Calendra minima*, (?)

Elymus robustus, Robust Wild Rye.

Calendra parvula.

Elymus striatus, Slender Wild Rye.

Calendra minima.

Sitanion elymoides, Long-bristled Wild Rye.

Calendra parvula.

Hystrix patula, Bottle-brush Grass.

Calendra minima.

CYPERACEÆ (Sedge Family).

Cyperus schweinitzii, Schweinitz's Cyperus.

Calendra callosa.

Cyperus pseudovegetus, Marsh Cyperus.

Calendra cariosa, Beaked-rush Billbug. *Calendra callosa*.

Cyperus rotundus, Nut Grass; Coco Grass.

Calendra cariosa. *Calendra scoparia*, (?) *Calendra callosa*.

Cyperus esculentus, Yellow Nut-grass.

Calendra cariosa. *Calendra parvula*. *Calendra destructor*. *Calendra callosa*. *Calendra venatus*.

Cyperus erythrorhizos, Red-rooted Cyperus.

Calendra cariosa. *Calendra callosa*.

Cyperus ferax, Coarse Cyperus.

Calendra cariosa. *Calendra callosa*.

Cyperus strigosus, Straw-colored Cyperus.

Calendra cariosa. *Calendra parvula*. *Calendra callosa*.

Cyperus ovularis, Globose Cyperus.

Calendra callosa.

Cyperus echinatus, Echinate Cyperus.

Calendra parvula.

Scirpus validus, American Great Bulrush; Mat-rush; Tule.

Calendra aequalis. *Calendra cariosa*. *Calendra costipennis*, Rib-

Winged Billbug. *Calendra discolor*, Tule Billbug. *Calendra incongrua*, Incongruous Billbug. *Calendra robusta*, Robust Billbug. *Calendra venatus*.

Scirpus fluviatilis, River Bulrush.

Calendra aequalis.

Scirpus atrovirens, Dark-green Bulrush.

Calendra cariosa. *Calendra scoparia*.

Scirpus eriophorum, Wool-grass.

Calendra cariosa.

Rynchospora corniculata, Beaked Rush.

Calendra costicollis v. *callosipennis*, Lake-bank Sedge Billbug.

Calendra cariosa. *Calendra callosa*.

Carex crus-corvi, Raven's Foot Sedge.

Calendra costicollis v. *callosipennis*.

Carex riparia, Lake-bank Sedge.

Calendra costicollis v. *callosipennis*. *Calendra scoparia*. *Calendra callosa*.

Carex comosa, Bristly Sedge.

Calendra costipennis.

Carex lupuliformis, Hop-like Sedge.

Calendra callosa.

Carex lupulina var. **pedunculata**, Hop Sedge.

Calendra costicollis v. *callosipennis*.

Carex vesicaria, Inflated Sedge. (?)

Calendra costicollis var. *callosipennis*. *Calendra scoparia*.

PONTEDERIAACEÆ (Pickerel-Weed Family).

Pontederia cordata, Pickerel-weed.

Calendra pontederiæ, Pickerel-weed Billbug.

JUNCACEÆ (Rush Family).

Juncus torreyi, Torrey's Rush.

Calendra destructor. *Calendra callosa*.

Juncus acuminatus, Sharp-fruited Rush.

Calendra destructor.

EXPLANATION OF PLATES.

PLATE I.

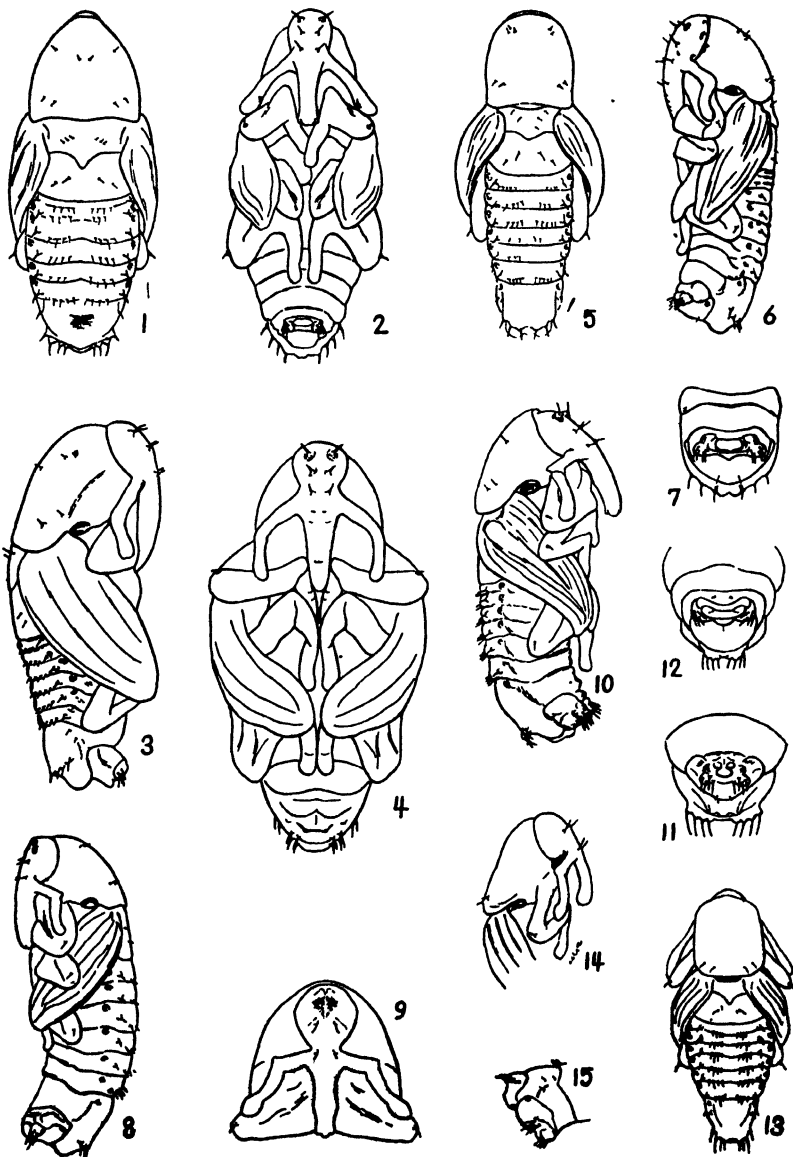
- FIGS. 1-4. *Calendra aequalis*. 1, Male, dorsal view, with two prolatero-pronotal setæ, four postlatero-pronotals, two medio-pronotals, spiraculo-pronotals (not shown), six mesonotals, and four metanotals. Formula: 2 4 2 ? 6 4. 2, Ventral view of same pupa. Rostral setæ 6. Setæ of tergite 8 wanting. 3, Lateral view of female. Setal formula: 4 4 2 0 4 4. Setæ of tergite 8 wanting. 4, Ventral view of same female. Rostral setæ 6. Setæ of tergite 8 wanting. Compare anal pattern with that of male.
- FIGS. 5-7. *C. discolor*. 5, Male, dorsal view. Setal formula: 6 4 0 ? 6 4, or 4 4 2 ? 6 4, the medio-pronotals having migrated to the prolatero-pronotal groups. 6, Lateral view of same pupa. Rostral setæ, 8. Setæ of tergite 8, 2, small. 7, Caudal end of abdomen, segments 7-10. Male type. Setæ of tergite 8, 2, small.
- FIGS. 8-9. *C. pertinax*. 8, Female, lateral view. Rostral setæ, 4; tubercles, 6; setæ of tergite 8, 0. 9, Head of same female.
- FIGS. 10-12. *C. ludoviciana*. 10, Female, lateral view. Rostrum with 6 setæ, basals on prominences overhanging laterad. Setal formula: 2 4 ? 4 ? ?. 11, Anal view of same female. Setæ of tergite 8, 2, small. 12, Anal view of male.
- FIGS. 13-15. *C. costicollis* var. *callosipennis*. Male. 13, Dorsal view. Setal formula: 0 4 0 ? 0 2. 14, Thorax, lateral view, same pupa. Only 4 tubercles, each seta-bearing. No spiraculo-pronotal setæ. 15, Lateral view of caudal end, no setæ on tergite 8.

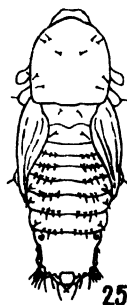
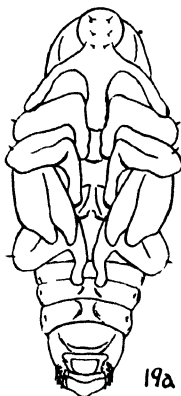
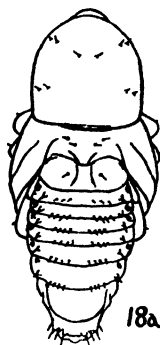
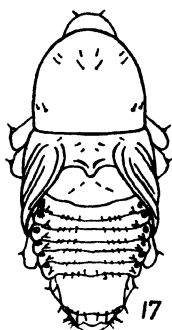
PLATE II.

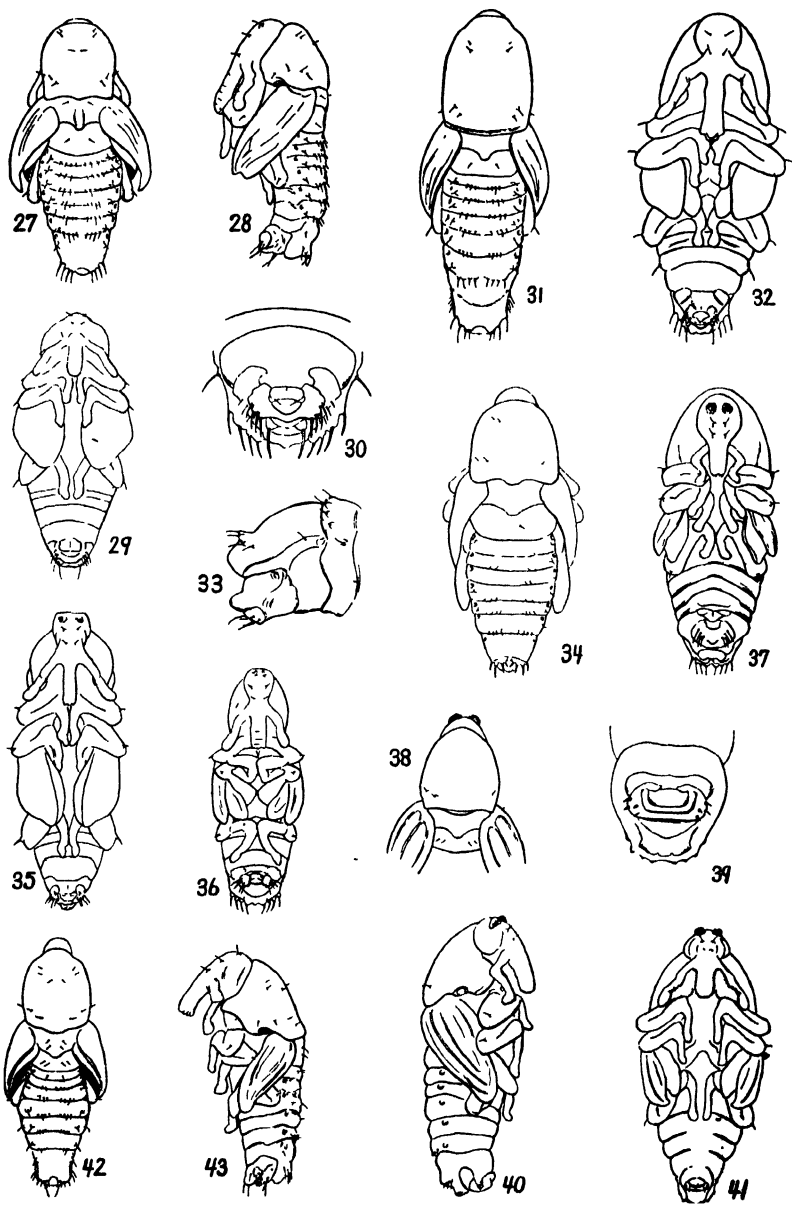
- FIGS. 16-17. *C. maidis*. 16, Female, lateral view. Setal formula: 4 4 4 ? 2 or 6 4. Rostrum, 6 setæ. Tergite 8, 0. 17, Dorsal view of same pupa: 4 4 4 ? 6 4.
- FIGS. 18a-18b. *C. cariosa*. 18a, Female, dorsal view. 18b, Same pupa, ventral view.
- FIGS. 19a-19b. *C. cariosa*. 19a, Male, ventral view. Rostrum, 6 setæ. Tergite 8, 0. Fig. 19b, Lateral view.
- FIGS. 20-22. *C. parvula*. 20, Male, lateral view. Rostrum, 4 tubercles only, each seta-bearing. Setæ of tergite 8, 2, large as largest on tergite 9. 21, Ventral view, same pupa. 22, Dorsal view of thorax of female. Setal formula: 4 4 0 ? 0 0.
- FIGS. 23-24. *C. minima*. Female. 23, Lateral view, rostrum with 6 setæ. Formula: 4 4 2 4 2 2. Setæ of tergite 8, 2, large. 24, Caudal view, same female.
- FIGS. 25-26. *C. retusa*. Female. 25, Dorsal view. Formula: 4 4 2 4 2 2. Setæ of tergite 8, 2, large. 26, Ventral view of same female. Rostral setæ, 6.

PLATE III.

- FIGS. 27-30. *C. destructor*. Female. 27, Dorsal view. Formula: 4 4 2 4 2 2. 28, Lateral view; rostrum with 6 setæ; tergite 8, 2, large, 6 small setæ. 29, Ventral view. 30, Caudal end.
- FIGS. 31-33. *C. scoparia*. 31, Female, dorsal view. Formula: 4 4 0 4 0 2. 32, Same pupa, ventral view, 4 rostral setæ, 4 rostral tubercles only. 33, Caudal end, no setæ on tergite 8.
- FIGS. 34-36. *C. callosa*. 34, Dorsal view. Formula: 4 4 0 ? 0 2. 35, Ventral view, same female. Rostrum with 6 setæ, basals small, on granular or excrescence-like prominences darker than head. 36, Male, ventral view.
- FIGS. 37-41. *C. melanocephala*. 37, Female, ventral view, rostrum with 6 tubercles, basals tall-rossetted, excrescence-like, without setæ; tergite 8 without setæ. 38, Dorsum of thorax, male. Formula: 0 4 0 ? 0 4. 39, Caudal end of same male. 40, Lateral view. 41, Ventral view, same male.
- FIGS. 42-43. *C. venatus*. Female. 42, Dorsal view. Formula: 4 4 2 4 4 4. Setæ of tergite 8, 2, large. 43, Same pupa, lateral view. Rostrum with 6 regular setæ.







ADDITIONS AND CORRECTIONS TO LINDSEY'S "TYPES OF HESPERIOID GENERA."

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In 1925, A. W. Lindsey* published a list of the Hesperioid genera and their types. The object of his catalog was to bring together a complete list of generic names that have been used in the family and to fix their genotypes by the International Rules of Zoological Nomenclature. Five hundred and seventy-four generic names were included by Lindsey in his list. Twenty-five additional ones have been found or have been proposed since its appearance. Naturally in a list of this size some omissions and errors are bound to occur. It has seemed advisable to bring the list up to date, including whatever corrections that could be made in the original one. The form used by Lindsey has been followed for the sake of uniformity.

Acknowledgment is due Dr. William Schaus for access to his library kindly given, and to Dr. A. W. Lindsey and Mr. R. C. Williams for their critical notes and remarks relative to the material presented herewith.

Preoccupied names are marked ‡.

Abantis

Haplotype *Abantis tellensis* Hopff.

1855, Hopff., Verh. Akad. Wissensch. Berl. 643.

1875, Scudder, Hist. Sk. 99. Cites *tellensis* as type (sole species).

Aguna

Orthotype *Eudamus camagura* Williams.

1927, Williams, Trans. Am. Ent. Soc. 53, 286. Cites *camagura* as type.

‡Anaperus

Diatype *Eudamus caicus* H.-S.

1919, Mabilie and Boulet, Ann. Sci. Nat., Zool. (x), 2, 232. Preoccupied by *Anaperus* Trosch., Ech., 1846, and by *Anaperus* v. Graffe, Verm., 1911. *Phoedinus* G. & S., which *Anaperus* M. & B. was to replace, is not preoccupied; apparently the spelling has been confused with that of *Phaedinus* Serv., Coleop., 1834.

Autochton

Haplotype *Autochton itylus* Hbn.

1823, Hübner, Zütrage Exot. Schmett., fig. 249-250. Sole species, *itylus*. If *itylus* is congeneric with *Cecropterus* species as it is given by Watson, Mabilie, and Draudt, the latter genus, *Cecropterus* H.-S., 1869 (type *sarex* Hbn. = *aunus* Fabr.), must fall.

*Lindsey, Ann. Ent. Soc. Am., XVIII, 75-106, 1925.

Brachycneme

1869, Herrich-Schaeffer, Corr.-Blatt. Regensb. 23, 138. In "Analyt. Table Genera"; no species given; also see p. 157 (1870).

1875, Scudder, Hist. Sk. 127. Says no species cited and falls because of *Brachycnemis* Schonh., Coleop., 1844.

Scudder's second objection does not hold according to the International Rules.

†Caecina

Logotype *Caecina calathana* Hew.

1868, Hewitson, Descr. Hesp. ii, 55. *Calathana* and *compusa*.

1875, Scudder, Hist. Sk. 129. Cites *calathana* as type.

1879, Plötz, Stett. Ent. Zeit. 40, 179. Cites *compusa* as type.

1893, Watson, Proc. Zool. Soc. Lond. 1893, 19. Cites *calathana* as type. Preoccupied by *Caecina* Stal, Hemip., 1863. *Ocyba* Lindsey, 1925, Ann. Ent. Soc. Am. 18, 94 erected to replace *Caecina* Hew.

Calleagris

Haplotype *Eagris jamesoni* E. Sharpe.

1925, Aurivillius in Seitz, Grossschmett, 13, 571. For *jamesoni* E. Sharpe.

Camptopleura

Logotype *Camptopleura theramenes* Mab.

1877, Mabilie, Pet. Nouv. Ent. ii, 166.

C. iphicrates Mab., is also described in a continuation of the same article on page 197 (1878).

Carcharodus

Logotype *Papilio alcea* Esp.

1820, Häbner, Verz. bek. Schmett. 110. *Lavathera* (!), *althea*, *alcea* and *malva*.

1879, Plötz, Stett. Ent. Zeit. 40, 179. Cites *alcea* Esp. as type.

1893, Watson, Proc. Zool. Soc. Lond. 1893, 44. Cites *lavatera* as type.

1925, Lindsey, Ann. Ent. Soc. Am. 18, 81. Confirms *lavatera* as type.

The type designations by Plötz in 1879 apparently were overlooked by Lindsey.

Chaetocneme

Logotype *Chaetocneme corvus* Feld.

1860, Felder, Sitzungsab. Acad. Wien xl, 460. *Corvus* and *cerinthus*, no type being cited.

1870, Butler, Ent. Mon. Mag. vii, 57. Cites *corvus* as type.

Corythaeolos

1904, Mabilie in Wytzman, Gen. Ins., Hesp. 105. Cites this generic name with the reference "Watson, Class. Hesp. p. 77 (1893)." (= *Koruthaialos* Watson, 1893).

Elwesia

Orthotype *Elwesia lesliei* Evans.

1926, Evans, Journ. Bomb. Nat. Hist. Soc. 31, 53. Cites *lesliei* Evans as type (sole species).

Eudamus (See *Goniurus*).**Eumesia**

Haplotype *Eumesia semiargentea* Feld.

1867, Felder, Reise Novara, 504. Sole species, *semiargentea*.

1870, Butler, Ent. Mon. Mag. vii, 96. States type is *semiargentea* Feld.

1875, Scudder, Hist. Sk. 171. Says preoccupied by *Eumesius* Westw. Hymen., 1840; but not so to be held according to the International Rules.

Goniloba

Logotype *Niconiades xanthaphes* Hbn.

1852, Westwood and Hewitson, Gen. Diurn. Lep. ii, 511.

1875, Scudder, Hist. Sk. 179. *Xanthaphes* is printed in bold-faced type, which with remarks in the introduction, constitutes a type fixation by Scudder.

GoniurusLogotype *Papilio proteus* Linn.

- 1820, Hübner, Verz. bek. Schmett. 104. *Simplicius, coelus, proteus*, etc.
 1862, Westwood and Hewitson, Gen. Diurn. Lep. ii, 510. Cite *proteus* as type.
 1870, Butler, Ent. Mon. Mag. vii, 56. Pseudotype *simplicious* Stoll.
 1875, Scudder, Hist. Sk. 180. Pseudotype *coelus* Cram.
 1879, Plötz, Stett. Ent. Zeit. 40, 178. Correctly cites *proteus* as type.
 1893, Watson, Proc. Zool. Soc. Lond. 20. Pseudotype *coelus* Cram.
 1916, Barnes & McDunnough, Contrib. iii, 2. Pseudotype *simplicius*.
 1922, Skinner & Williams, Trans. Am. Ent. Soc. 48, 115. Again cite *coelus* as type.
 1925, Lindsey, Ann. Ent. Soc. Am. 18, 98. Pseudotype *simplicius* Stoll.
 1929, Shepard, Ent. News 40, 233. *Proteus* cited as true type. *Eudamus* Swain. with type *proteus* becomes a synonym of *Goniurus* Hbn.

HalpeLogotype *Halpe beturia* Moore.

- 1878, Moore, Proc. Zool. Soc. Lond. 689. *Beturia, ceylonica* and others.
 1893, Watson, Proc. Zool. Soc. Lond. 93. Cites *beturia* as type.
 1925, Lindsey, Ann. Ent. Soc. Am. 18, 88. Pseudotype *ceylonica*. Zoo.
 Record for 1878 mentions five included species, but does not cite a type.

HewitsoniaOrthotype *Eudamus aenesius* Hew.

- 1926, Evans, Journ. Bomb. Nat. Hist. Soc. 31, 50. Cites *aenesius* as type.
 Preoccupied by *Hewitsonia* Kirby, Lycaenidæ, 1871. See *Hewitsoniella*.

HewitsoniellaDiatype *Eudamus aenesius* Hew.

- New name for *Hewitsonia* Evans, preoccupied.

MimambrixHaplotype *Mimambrix woolletti* Riley.

- 1923, Riley, Entomologist 56, 37. *Woolletti* Riley, sole species.

MooreanaOrthotype *Pterygospidea trichoneura* Feld.

- 1926, Evans, Journ. Bomb. Nat. Hist. Soc. 31, 51. Cites *trichoneura* Feld. as type.

NicevilleaOrthotype *Pamphila gola* Moore.

- 1926, Evans, Journ. Bomb. Nat. Hist. Soc. 31, 57 and 623. Cites *gola* as type.

OrthophaetusDiatype *Eudamus phanaeus* Hew.

- 1895, Watson, Journ. Bomb. Nat. Hist. Soc. 9, 419 and 422. Not spelled *Orthophoetus*. New name for *Pteroxys* Watson, which see.

ParonymusLogotype *Hesperia ligora* Hew.

- 1925, Aurivillius in Seitz. Grossschmett 13, 520. For six species including *ligora* Hew., which may be taken as genotype.

PelliciaLogotype *Pellicia dimidiata* H.-S.

- 1870, Herrich-Schäffer, Corr.-Blatt Regensb. 159, referring the genus to Plötz.
 1875, Scudder, Hist. Sk. 243. Cites *dimidiatus* as type.
 1879, Plötz, Stett. Ent. Zeit. 40, 176 and 179. Uses *Pellicia* n. g. and cites *macarus* H.-S. as type.

PereneiaOrthotype *Pereneia pandora* Lindsey.

- 1925, Lindsey, Denison Univ. Bull. 25, 107. One species, *pandora*.

PlthauriopsisLogotype *Pithauriopsis aitchisoni* W.-M. & de Nicev.

- 1886, Wood-Mason and de Niceville, Journ. Asiat. Soc. Bengal, 4, 387. Describe *aitchisoni* and *stramineipennis*.
 1925, Lindsey, Ann. Ent. Soc. Am. 18, 97. Gives *aitchisoni* as "haplotype;" of the two new species originally described in this genus, *aitchisoni*, designated by Lindsey, may be considered logotype.

PolaOrthotype *Ismene ataphus* Wats.

1912, Swinhoe, Lep. Ind. ix, 226. Date and page incorrect in Lindsey's article.

†PteroxysOrthotype *Eudamus phanaeus* Hew.

1893, Watson, Proc. Zool. Soc. Lond. 29.

1895, Watson, Journ. Bomb. Nat. Hist. Soc. 9, 419. Gives new name *Orthophaetus*, *Pteroxys* Watson being preoccupied by *Pteroxys* Hampson, 1893, Psychidæ. See *Orthophaetus*.**†Ramburia**Orthotype *Pyrgus antonia* Speyer.1926, Warren, Trans. Ent. Soc. Lond. 14. Cites *antonia* Speyer as type. Preoccupied by *Ramburia* Desv., Diptera, 1851. See *Warrenohesperia*.**Reverdinia**Orthotype *Pyrgus staudingeri* Speyer.1926, Warren, Trans. Ent. Soc. Lond. 14. Cites *staudingeri* as type.**Reverdinus**Logotype *Carcharodus altheæ* Hbn.1919, Ragusa, Naturalista Sicil. 23, 172. Includes *altheæ* Hbn., *baeticus* Ramb. and *flociferæ* Zell., but does not cite a type.1925, Lindsey, Ann. Ent. Soc. Am. 18, 100. Cites *altheæ* as type.**Sartora**Orthotype *Ismene ionis* de Nicev.

1912, Swinhoe, Lep. Ind. ix, 229.

Scelotrix (not *Scelothrix*)Logotype *Scelotrix carthami* Ramb.

1858, Rambur, Cat. Lep. Andal. i, 63.

1879, Plötz, Stett. Ent. Zeit. 40, 179. Cites *sidæ* as type, but *sidæ* is not given by Rambur in the original article.1893, Watson, Proc. Zool. Soc. Lond. 65. Cites *carthami*, Rambur's first species, as type.1916, Barnes and McDunnough, Contrib. iii, 121. Pseudotype *malvæ*.1925, Lindsey, Ann. Ent. Soc. Am. 18, 100. Cites *carthami*.**Seseria**Orthotype *Suastus nigroguttatus* Mats.

1919, Matsumura, Thousand Insects of Japan, Addit. 3, 683.

SymmachiaDiatype *Papilio comma* Linn.1837, Sodoffsky, Bull. S. I. Mosc. 10 (7), 120. Suggested in place of *Hesperia*!**Syrictus**Logotype *Papilio sao* Bergst.

1832-3, Boisduval, Icones, 230.

1879, Plötz, Stett. Ent. Zeit. 40, 179. Cites *sao* Bergst. as type.1879, Elwes and Edwards, Rev. Orient. Hesp. 153. Cite *proto* as type.**Tarmia**Orthotype *Tarmia monastica* Lindsey.1925, Lindsey, Denison Univ. Bull. 25, 110. One species, *monastica*.**Tmetocerus**1895, G. A. Poujade, Ann. Soc. Ent. France 64, cxliv. "*Thymele* Hbn. (ex parte)". Gives "*Tmetocerus* P. Mab." under which is included *asander*.**Tuttila**Orthotype *Papilio tessellum* Hbn.1926, Warren, Trans. Ent. Soc. Lond. 14. Cites *tessellum* Hbn. as type.**Warrenohesperia**Diatype *Pyrgus antonia* Speyer.1926, Strand, Arch. Naturg. 92, A8, 74. New name for *Ramburia* Warren, preoccupied.**Xanthodisca**Haplotype *Astictopterus vibius* Hew.1925, Aurivillius in Seitz, Grossschmett, 13, 528. For *vibius* Hew.**Zehala**Orthotype *Ismene striata* Hew.

1912, Swinhoe, Lep. Ind. ix, 229.

NOTES ON DIGESTION IN SEVEN SPECIES OF INSECTS.*

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During the spring of 1928 some experiments were performed on a number of insects to determine any differences in their abilities to digest certain classes of foods. It seemed important to determine if the specificity of the feeding habits of insects could be linked with their respective abilities to digest various classes of foods.

The specimens used for the work were dissected and a portion of the material to be tested was removed and mixed with the food to be digested in a micro-tube. Check tubes containing boiled material were incubated under the same conditions as the active tubes. All tubes were capped with toluene to prevent the entrance of micro-organisms from the air, and were then allowed to incubate for at least 48 hours at room temperature. Methods used in testing for the end-products of digestion were similar to those outlined by Hawk and Bergeim (1), and Swingle (2).

RESULTS.

TABLE I.
AMERICAN LOCUST (*Schistocerca americana*), ORDER ORTHOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED**				
	Starch	Maltose	Sucrose	Fats	Proteins
Salivary glands	+	—	—	—	—
Fore gut tissue	—	+	+	—	—
Gastro coeca	—	+	+	+	+
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	+	+	+	—	—
Mid gut contents	+	+	+	+	+
Hind gut contents	+	+	+	+	+

** "+" indicates digestion; "—" indicates no digestion, a blank space indicates that no test was made.

*Contribution No. 68. Research Laboratories, Moorestown, New Jersey.

TABLE II.

CHINESE MANTIS (*Paratenodora sinensis* Sauss.), ORDER ORTHOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Salivary glands	+	+	+	—	—
Fore gut tissue	—	+	+	—	+
Gastric coeca	—	+	+	—	—
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	+	+	+	—	+
Mid gut contents	+	+	+	+	+
Hind gut contents	—	+	+	+	+

TABLE III.

A DRAGONFLY (*Libellula lucinosa* Berm.), ORDER ODONATA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	—	+	+	—	—
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	—	+	+	+	+
Mid gut contents	—	+	+	+	+
Hind gut contents	—	+	+	+	+

TABLE IV.

SPOTTED GRAPEVINE BEETLE (*Peltidota punctata* L.), ORDER COLEOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	—	+	+	—	—
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	—	+	+	—	—
Mid gut contents	—	+	+	+	+
Hind gut contents	—	+	+	+	+

TABLE V.

SPOTTED GRAPEVINE BEETLE (*Pelidnota punctata* L.), ORDER COLEOPTERA, LARVA.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	—	+	+	—	—
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	+	+	+	+	+
Mid gut contents	+	+	+	+	+
Hind gut contents	+	+	+	+	+

TABLE VI.

RED MILKWEED BEETLE (*Tetraopes tetraophthalmus* Forst.), ORDER COLEOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	—	+	+	—	—
Mid gut tissue	—	+	+	—	—
Hind gut tissue	—	—	—	—	—
Fore gut contents	—	+	+	—	+
Mid gut contents	—	+	+	+	+
Hind gut contents	—	+	+	+	—

TABLE VII.

PROMETHEA MOTH (*Callosamia promethea* Drw.), ORDER LEPIDOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Fore gut tissue	—	+	—	+	
Mid gut tissue	—	+	—	+	
Hind gut tissue	—	—	—	—	
Fore gut contents	—	+	—	+	
Mid gut contents	—	+	—	+	
Hind gut contents	—	+	—	—	

TABLE VIII.

A BUMBLEBEE (*Bremus ferridus* Fab.), ORDER HYMENOPTERA, ADULT.

EXTRACT	MATERIAL DIGESTED				
	Starch	Maltose	Sucrose	Fats	Proteins
Salivary glands	+	—	—	—	—
Fore gut tissue	—	+	+	—	+
Mid gut tissue	—	+	+	+	+
Hind gut tissue	—	—	—	—	—
Fore gut contents	+	+	+	—	+
Mid gut contents	+	+	+	+	+
Hind gut contents	+	+	+	+	+

SUMMARY.

Extracts were made of the various regions of the digestive tract in seven species of insects and were tested for their power of digesting five different food materials. Only slight differences in digestion were found among the different species. None of these could be linked with the great specificity of feeding habits in the insects.

Extracts of the tissue of the hind gut of each insect failed to digest any of the food materials used.

LITERATURE CITED.

- (1.) **Hawk, P. B., and Bergelm, O.** Practical physiological chemistry, 9th edition, pp. 41-244, pls. 3 and 4, figs. 12A-73. P. Blakiston's Son and Company, Philadelphia. 1927.
- (2.) **Swingle, H. S.** Digestive enzymes of the Oriental Fruit Moth. *Annals Ent. Soc. Amer.* 21: 469-475. 1928.

NEW NORTH AMERICAN SARCOPHAGIDÆ.

DAVID G. HALL,
U. S. Bureau of Entomology.

Two undescribed species of Sarcophagidæ which belong to the Chaetoravinia group have come to hand since the publication of my paper, "*Sarcophaga pallinervis* and Related Species in the Americas."* These are described below, and a key is presented to separate them from those species with which they might be confused.

1. Fourth abdominal segment and first segment of the hypopygium black.... 2
Fourth abdominal segment partially red; first segment of the hypopygium red..... 3
2. Outer verticals present in male..... *S. latisetosa* Park.
Outer verticals absent..... *S. stimulans* Walk.
3. Outer verticals present..... *S. laakei* n. sp.
Outer verticals absent..... 4
4. Anterior clasper of male elongate, curved strongly forward; anterior plates of penis elongate and at right angles to stalk..... *S. effreneta* Walk.
Anterior clasper heavy, only slightly curved forward to a blunt tip; anterior edge of clasper transparent; penis essentially as in *S. stimulans* Walk..... *S. coachellensis* n. sp.

Sarcophaga laakei n. sp.

Male: Chaetotaxy essentially as in *S. latisetosa* Parker, which has been so well described that there is no need to repeat the characters here. The main differences are listed in the key. In addition to these, the anterior clasper of *S. latisetosa* appears slightly dished inwardly at the tip, sometimes giving the impression of a double tip. This is not the case in *S. laakei*.

Holotype: No. 43264, U. S. National Museum, collected during the period August 26 to September 6, 1929, at Menard, Texas, selected from a series of five male specimens chosen as the type and paratype series. These were trapped by Mr. E. W. Laake and Mr. E. C. Cushing in standard traps baited with decaying beef.

This species appears to be one of the most common species of *Sarcophaga* in Texas, and probably takes the place of *S. latisetosa* Parker in the south, much as *S. sueta* v. d. W. takes

*Hall, 1928, Ann. Ent. Soc. Amer., Vol. XXI, p. 331-352.

the place of *S. lhermenieri* R. D. Both *S. latisetosa* and *S. lhermenieri* R. D. are very common in the northern part of North America.

Sarcophaga coachellensis n. sp.

Male: Chaetotaxy essentially as in *S. quadrisetosa* Coq. but differing from this species, as well as others closely related, in the form of the anterior clasper, as listed in the key.

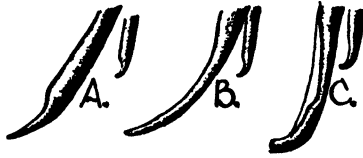


FIGURE 1. A, Claspers of *S. stimulans* Walk. B, Claspers of *S. laakei* n. sp.
C, Claspers of *S. coachellensis* n. sp.

Holotype: No. 43265, U. S. National Museum, selected from a series of ten specimens which have been taken as the type and paratype series, these being from a good number trapped at Coachella, California, during the summer of 1929 in traps which were baited with decaying liver, urea, and water.

PROCEEDINGS OF THE TWENTY-FIFTH ANNUAL MEETING.

Cleveland, Ohio, December 30 and 31, 1930.

The twenty-fifth annual meeting of the Entomological Society of America was held at Cleveland, Ohio, December 30 and 31, 1930. The program of forty-four papers was unusually interesting and touched almost every field in entomology. Approximately 200 members attended one or more sessions.

The Annual Public Address was given by Prof. H. J. Quayle, in the Auditorium of the Cleveland Museum of Natural History, and was attended by 1000 persons. The subject of Professor Quayle's illustrated talk was "Entomologists of Subtropical Countries," and was thoroughly appreciated by all.

Owing to difficulties arising at a late date which could not be overcome, the symposium, which had been an annual feature of our meetings, was omitted.

Opening Session, Tuesday Morning, December 30th.

The Society was called to order at 10:00 A. M., by President Edith M. Patch, in Room 105, Chemistry Laboratory, Case School of Applied Science, Cleveland, Ohio. The following papers were presented, either by the author or by title:

1. The Composition and Origin of the Insect Fauna of Hot Springs in the Western United States. (Slides and Moving Pictures.) C. T. BRUES, Harvard University.
2. Insect Life of Oklahoma Salt Plains. (Lantern.) R. D. BIRD, University of Oklahoma.
3. Preliminary Survey of the Aquatic Coleoptera of Presque Isle, Erie, Pa. (By Title.) JOHN T. GAMBLE, Greenville, Pa.
4. A Flying Trip for Dragonflies to the West Indies. (Lantern.) J. G. NEEDHAM, Cornell University.
5. Notes on the Geographical Distribution of Florida Odonata. C. FRANCIS BYERS, University of Florida.
6. A Gynandromorph of *Chironomus decorus*. O. A. JOHANNSEN, Cornell University.
7. Concerning Some Recent Trends and Suggestions in Taxonomy. C. H. CURRAN, American Museum of Natural History.
8. Classifying Symbols or a Placing System for Insects. E. P. FELT, Bartlett Research Laboratory.
9. The Genus *Xerophoea* (Homoptera, Cicadellidæ). (Lantern.) PAUL B. LAWSON, University of Kansas.
10. On the Length of the Adult Life in the Webbing Clothes Moth (*Tineola biselliella* Hum.) (Chart.) GRACE H. GRISWOLD, Cornell University.

The following committees were appointed by President Patch:

Nominating Committee—C. T. BRUES, Chairman; ARTHUR GIBSON, F. E. LUTZ.

Auditing Committee—C. L. METCALF, Chairman; T. H. FRISON, C. R. CROSBY.

Resolutions Committee—O. A. JOHANNSEN, Chairman; W. V. BALDUF, A. F. SATTERTHWAIT.

Second Session, Tuesday Afternoon, December 30th.

The Society was called to order by President Patch at 1:35 P. M. The following papers were presented:

11. European Entomologists and European Museums. (Lantern.) H. B. HUNGERFORD, University of Kansas.
12. Some Notes on Early Work in Entomology in Ohio. (Lantern.) HERBERT OSBORN, Ohio State University.
13. Mounting Coleoptera. (See Exhibits.) HENRY DIETRICH, Mississippi State Plant Board.
14. A Revision of Recent and Fossil Termopsinæ (Isoptera). (By Title.) ALFRED E. EMERSON, Chicago University.
15. A Study of the Genus *Nemobius* (Orthoptera, Gryllidæ). (Lantern.) B. B. FULTON, North Carolina Agricultural College.
16. The Larvæ of the Army Ants. (Lantern.) GEORGE C. WHEELER, University of North Dakota.
17. Evidence that *Macrocentrus ancylivora* Roh. and *M. delicatus* Cress., Parasitic on the Oriental Fruit Moth, are Morphologically and Physiologically Distinct Species. BYRLEY F. DRIGGERS and B. B. PEPPER, New Jersey Agricultural Experiment Station.
18. *Tibicen davisi*: A New Insect in the Field of Economic Entomology. (Lantern.) J. W. WILSON, Pierson, Florida.
19. Penetration of Petroleum Oils into Leaves and Twigs. (Lantern.) JOSEPH M. GINSBURG, New Jersey Agricultural Experiment Station.
20. Mosquito Control Work in Massachusetts. GEORGE S. TULLOCH, Museum of Comparative Zoology.
21. Insects in Relation to Plant Diseases. A. A. GRANOVSKY, University of Minnesota.

Third Session, Tuesday Evening, December 30th.

The Society was called to order by President Patch at 7:30 P. M., this evening session being held in the Auditorium of the Cleveland Museum of Natural History. The President introduced Prof. H. J. Quayle, who gave the annual address. Doctor Quayle's address, which was illustrated, was on "Entomologists in Subtropical Countries."

Fourth Session, Wednesday Morning, December 31st.

The Society was called to order by President Patch at 9:30 A. M. The following papers were presented:

22. The Habits of Leaf-mining Coleoptera from Panama. (By Title.) S. W. FROST, Pennsylvania Agricultural Experiment Station.
23. Notes on the Biology of the Stable Fly, *Stomoxys calcitrans* Linn. (By Title.) ROY MELVIN, Iowa State College.
24. The Bionomics of *Lipeurus heterographus* Nitzsch (Mallophaga), the Common Head Louse of Fowls: With Notes on Other Fowl Infesting Species. (Lantern.) F. H. WILSON, University of Richmond.
25. The Biology of *Tabanus lineola* Fabr. H. H. SCHWARDT, University of Arkansas.
26. Notes on Life History and Description of *Systelloderes biceps* Say, (Hemiptera, Enicocephalidæ). (Lantern.) A. F. SATTERTHWAIT, U. S. Bureau of Entomology.
27. Field Notes on Some Colorado Mosquitoes. (Lantern.) SHERMAN C. BISHOP, University of Rochester.
28. Studies on the Biology of *Paratrissia cockerelli* Sulc. GEORGE F. KNOWLTON and M. J. JONES, Utah University Agricultural Experiment Station.

29. Notes on Seventeen Year Cicadas in Kansas. R. H. BEAMER, University of Kansas.
30. The Magnolia Scale (*Neolecanium cornuparvum*). (Lantern.) GLENN W. HERRICK, Cornell University.
31. A Trip to Grasshopper Glacier. (Lantern.) GEORGE E. MARVIN, University of Wisconsin.
32. The Blueberry Maggot from an Ecological Viewpoint. F. H. LATHROP and C. B. NICKELS, U. S. Bureau of Entomology.
33. The Life History of *Hippelates pusio* Lw. in Coachella Valley, California. (Lantern.) DAVID G. HALL, U. S. Bureau of Entomology.
34. A Fourth Aquatic Hemipteron Having Only Four Nymphal Stages. WILLIAM E. HOFFMAN, Lingman University.
35. Notes on the Biology of Burrowing Mayflies. (Lantern.) ANN H. MORGAN, Mount Holyoke College.
36. Insects That Bite Man. (Lantern.) C. L. METCALF, University of Illinois.

Fifth Session, Wednesday Afternoon, December 31st.

The Society was called to order by President Patch at 1:30 P. M.
The following papers were presented:

37. Factors Determining the Production of Winged and Sexual Forms of *Aphis spiraeicola* on Citrus. J. R. WATSON, Florida Agricultural Experiment Station.
38. Tropisms and Sense Organs of Coleoptera. (Lantern.) N. E. MCINDOO, U. S. Bureau of Entomology.
39. The Proboscis Reflex of Insects. (Blackboard.) CYRIL E. ABBOTT, Ohio State University.
40. Anaphylactic Shock Following the Sting of *Vespa*. C. T. BRUES, Harvard University.
41. A Preliminary Report on Chironomid Larvæ Associated with Watersnails. (Lantern.) CLARENCE H. HOFFMAN, University of Kansas.
42. Importance of the Sex Ratio in Breeding Parasites. PHILIP GARMAN and JOHN C. SCHREAD, Connecticut Agricultural Experiment Station.
43. A Flying Trip among the Entomologists of the West Indies. JAMES G. NREDHAM, Cornell University.
44. Measure of Adhesiveness Strengths of Calcium Arsenate. J. A. PARFENTJEV, St. Louis, Mo.

First Vice-President Snodgrass was called to the chair. The Annual Business Meeting followed.

REPORT OF THE SECRETARY.

Previous to July 1, 1930, the following, having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

- EDWIN J. ANDERSON, Agricultural Experiment Station, State College, Pa.
 JOHN WENDELL BAILEY, University of Richmond, Richmond, Va.
 HORACE E. BELL, 56 Park St., Orono, Maine.
 STEPHAN COLE BRUNER, Estacion Experimental Agronomica, Santiago de las Vegas, Havana, Cuba.
 OWEN BRYANT, Banff, Alberta, Canada.
 HORACE LESTER CALER, Box 12, Addison, Maine.
 L. DEAN CHRISTENSON, Central Baragua, Camaguey, Cuba.
 LAWRENCE H. DUNN, Gorgas Memorial Laboratory, Ancon, Canal Zone.
 LONNIE CLIFTON ELMORE, Fork Union Military Academy, Fork Union, Va.
 DONALD W. FARQUHAR, 296 Ames St., Lawrence, Mass.
 ARTHUR MERTON GILLESPIE, Phi Eta Kappa, University of Maine, Orono, Maine.
 MISS CHRISTINE HARDY, Dept. Entomology, Cornell University, Ithaca, N. Y.

- GORDON W. HAUG, Dept. Entomology, A. & M. College, Mississippi.
 H. A. JAYNES, Casilla Correo 74, Tucuman, Argentina.
 BIRLEY J. LANDIS, 153 Calzada Tacuba, San Jacinto, District Federal, Mexico City, Mexico.
 ULPHIAN CARR LOFTIN, Cuba Sugar Club Expt. Station, Central Baragua, Camaguey, Cuba.
 ALONZO WILLIAM LOPEZ, P. O. Box 1493, Manila, Philippine Islands.
 YUSHIRO MIWA, Dept. Agriculture, Government Research Institute, Taihoku, Formosa.
 L. E. MYERS, Miss. St. Pl. Bd., A. & M. College, Mississippi.
 ROBLEY WILSON NASH, Forest Service, State House, Augusta, Maine.
 A. GLEN RICHARDS, JR., Dept. Entomology, Cornell University, Ithaca, N. Y.
 LUIS C. SCARAMUZZA, Central Jaronu, Camaguey, Cuba.
 GEDDIS W. SIMPSON, Dept. Entomology, Cornell University, Ithaca, N. Y.
 JOHN W. WILSON, Pierson, Florida.
 LOUIS W. ZIEGLER, Agricultural Experiment Station, Gainesville, Florida.

With the approval of the Executive Committee, Prof. H. J. Quayle was invited to give the annual public address of the Society at the Cleveland meeting.

J. S. Houser kindly consented to act as chairman of the Arrangements Committee. He was ably assisted by J. C. Pallister.

During the year the following appointments were made by President Patch:

Dr. J. N. Chapman was appointed the Society representative for the Division of Biology and Agriculture of the National Research Council. Owing to his transfer of residence to Hawaii, Doctor Chapman resigned the appointment and Dr. F. E. Lutz was appointed to fill the vacancy.

Dr. E. D. Ball was appointed to represent the Society at the inauguration of Doctor Shantz as President of the University of Arizona.

The Executive committee met at 4:30 P. M., December 30, in the Library Room of the Chemical Laboratory, Case School of Applied Science, the following members being present: Edith M. Patch, Herbert Osborn, C. L. Metcalf, P. J. Parrott, and J. J. Davis. F. E. Lutz was also present as an alternate designated by the President.

The following were elected to membership in the Society:

- ERNEST ADNA BACK, Bur. Entomology, U. S. Dept. Agric., Washington, D. C.
 SAMUEL C. BILLINGS, Insecticide Testing Labry., R. No. 1, Silver Spring, Md.
 EBER CECIL BARR, 1471 Michigan Ave., Columbus, Ohio.
 JAMES MARKS BRENNAN, Dept. Entomology, Kansas University, Lawrence, Kansas.
 FERDINAND H. BUTT, 708 Stewart Ave., Ithaca, N. Y.
 M. T. CHEO, Dept. Entomology, Cornell Univ., Ithaca, N. Y.
 WILLIAM HODGES CLARKE, Peach Experiment Station, Thomaston, Ga.
 RALPH H. DAVIDSON, Dept. Entomology, Ohio State Univ., Columbus, Ohio.
 ERNEST J. DORNFELD, 212 E. North Ave., Milwaukee, Wis.
 MISS DOROTHY DOTTERER, Dept. Zoology, Univ. Pittsburgh, Pittsburgh, Pa.
 RAY THOMAS EVERLY, 425 Fourth St., Toledo, Ohio.
 LOWELL J. FARMER, Moscow, Idaho.
 STANLEY E. FLANDERS, Citrus Expt. Station, Riverside, Calif.
 CHARLES E. FOSTER, Colgate University, Hamilton, N. Y.
 H. T. FENG, Dept. Entomology, Cornell Univ., Ithaca, N. Y.
 GEORGE H. GEISSLER, Box 167, Vincennes, Ind.
 NEWELL E. GOOD, 2000 H. St., N. W., Washington, D. C.
 LOUISE ELIZABETH HAAS, Dept. Zoology, Iowa State College, Ames, Iowa.
 ROWLAND WELLS HAEGELE, Dept. Entomology, Idaho Agr. Expt. Station, Parma, Idaho.
 HELEN FOWLER HAYDEN, 207 Fall Creek Drive, Ithaca, N. Y.
 CHARLES H. HICKS, 823 Harvard Rd., Burbank, Calif.
 SAM ODOM HILL, 10 Court St., Arlington, Mass.
 WILLIAM BURNELL HOLLINGSWORTH, Box 415, Picayune, Miss.

- Y. C. HSU, Dept. Entomology, Cornell Univ., Ithaca, N. Y.
 MISS GWLADYS HUGHES, Dept. Entomology, Cornell Univ., Ithaca, N. Y.
 ROSS ELLIOTT HUTCHINS, State Pl. Bd., A. & M. College, Mississippi.
 MELVIN J. JANES, Utah Agr. Expt. Sta., Logan, Utah.
 S. E. JONES, Texas Agr. Expt. Sta., College Station, Texas.
 SHIZUO KATO, Entomological Institute, Hokkaido Imperial University, Sapporo, Japan.
 EDWARD F. KNIPLING, 2121 Lincoln Way, Ames, Iowa.
 ERSKINE M. LIVINGSTONE, 515 Jefferson St., Danville, Va.
 JAMES MARION MCGOUGH, Estacion E. Agronomica, Santiago de las Vegas, Havana, Cuba.
 A. GORDON McNALLY, 390 Colborne St., London, Ontario, Canada.
 L. CHESTER MORSTON, Jr., Dept. Biology, Univ. Toronto, Toronto, Canada.
 H. C. MASON, 151 W. Eleventh Ave., Columbus, Ohio.
 FORREST W. MILLER, Dept. Zoology, University of Pittsburgh, Pittsburgh, Pa.
 RONALD C. MUNDELL, Box 509, Uvalde, Texas.
 A. MUSGRAVE, Australian Museum, Sydney, N. S. W., Australia.
 BAILEY B. PEPPER, Dept. Entomology, Ohio State University, Columbus, Ohio.
 DON M. REES, University of Utah, Salt Lake City, Utah.
 PAUL E. SCHAEFER, Dept. Entomology, Ohio State University, Columbus, Ohio.
 MORRIS SCHLOSBERG, 615 Front St., Toledo, Ohio.
 S. W. SIMMONS, A. & M. College, Mississippi.
 E. GRAYWOOD SMYTH, Hacienda Cartavio, Salaverry, Peru.
 BENJAMIN R. SPEICKER, Dept. Zoology, Univ. Pittsburgh, Pittsburgh, Pa.
 J. SEDLEY STANFORD, Utah State Agr. College, College Hill, Logan, Utah.
 WILLIAM WALTER STANLEY, Tennessee Agr. Exp. Sta., Knoxville, Tenn.
 A. L. STRAND, Montana State College, Bozeman, Montana.
 MISS JAY R. TRAVER, Dept. Entomology, Cornell University, Ithaca, N. Y.
 BENARD V. TRAVIS, Dept. Zoology, Iowa State College, Ames, Iowa.
 HARRY GRANVILLE WALKER, Virginia Truck Exp. Sta., Norfolk, Va.
 RUSSELL R. WHITTEN, 104 Ashland St., Melrose, Mass.
 MISS INEZ WILLIAMS, Fernald Hall, Amherst, Mass.
 GEORGE CHARLES WOODRUFF, Box 615, University Station, Baton Rouge, La.
 ARCHIBOLD MCFARLAND WOODSIDE, Dept. Entomology, Virginia Agr. Exp. Sta., Blacksburg, Va.

Total new members during 1930—80.

The following three members paid \$50.00, thereby becoming Life Members:

MRS. GASTON FOURNIER.
 MISS EDITH W. MANK.
 DR. C. W. JOHNSON.

The following were elected Fellows of the Society:

H. G. BARBER,	W. D. PIERCE,
HENRY BIRD,	A. F. SATTERTHWAIT,
D. M. DeLONG,	O. H. SWEZEY,
W. T. M. FORBES,	M. C. VANDUZEE.
R. JEANNEL,	

The following members have resigned during the year: H. C. ATWELL, MARTIN BOWE, E. H. WHEELER, M. C. MARSHALL, M. B. DUNN, JOSEPH KRAFKA, JR., FRED E. POMEROY, KARL W. JOHNSON, A. A. MATHEWSON, T. E. SNYDER.

The following members have been automatically dropped from the membership list: ALICE P. MACDOUGAL, LAUREL SETTY, FRED M. BROWN, ERNEST A. NEILSON.

The Society has suffered the loss of the following members:

FRANK A. LEACH died last year, June 19, 1929, but was not recorded in the minutes of the last meeting.

STEPHEN ALFRED FORBES died March 13, 1930, at the age of 85 years and 9 months. He was the President of this Society in 1912, and one of the outstanding entomologists of the world. His remarkable record, not only as an entomologist, but as an ornithologist, an ichthyologist, and as an ecologist are vouched for by his writings and the fact that he was variously known as "Dean of American Economic Entomologists," as "The First Economic Ornithologist in America," and as "The Founder of the Science of Ecology." Quoting the last paragraph in an obituary written by Dr. Metcalf and published in the May, 1930, *Entomological News*: "Fearless, eternally youthful, unostentatiously confident and inspiring, never seeking favor or preferment, but continually in demand by recognition of his worth, this man was revered by his peers and colleagues for his breadth and clarity of vision, his kindly, helpful criticism and sympathy, his infectious enthusiasm, his brilliant intellect and impregnable strength of character, and his loyal and genial friendship."

DR. WILLIAM BARNES died May 1, 1930. A surgeon of national reputation, he became even more famed by his vocation as a Lepidopterist. The remarkable collection of Lepidoptera which he built up and the valuable monographs which he published will ever stand as a monument to his greatness as a taxonomist.

DR. H. J. PACK died June 5, 1930.

DR. M. M. WELLS died August, 1930. He was president of the General Biological Supply House of Chicago and was always interested in promoting entomology and allied subjects. He was scientifically trained and was a genuine scientist. At the time of his death, he was preparing a Field Book in Biology and his training and interest assured a valuable and useful work.

REV. V. A. HUARD died October 15, 1930.

DR. J. H. EMERTON died December 5, 1930, in his eighty-fourth year. He was for many years interested in entomology and is known to us as one of the best known authorities on spiders.

GEORGE G. AINSLIE died December 20, 1930. He was for many years connected with the Cereal and Forage Insect Division of the Federal Bureau of Entomology and is especially known for his economic and taxonomic work on the Crambidae.

PROF. J. S. HINE died December 22, 1930. He was a teacher of ability and well known to the entomological fraternity as a taxonomist in the Order Diptera. But to those who knew him intimately, he was appreciated because of his helpful and kindly ways.

Prof. Herbert Osborn was appointed as elector to select the Society Representative for the Division of Biology and Agriculture of the National Research Council.

The matter of a National Biological Society was laid on the table without action.

It was recommended to the Society that it again contribute \$25.00 to the Zoological Record.

A report was received from Arthur Gibson, who represented the Society at the Third Imperial Entomological Conference, held in London. Mr. Gibson presented greetings from our Society and in return was thanked for the greetings extended and was requested to present to our Society the good wishes of the Conference for the future success of the Entomological Society of America.

It was recommended that hereafter there should be a committee of one to present Memorials at each annual meeting.

The committee recommended the appointment of the following members on the Editorial Board: J. McDUNNOUGH, HENRY BIRD, and E. B. WILLIAMSON.

Respectfully submitted,

J. J. DAVIS, *Secretary*.

On motion the Secretary's Report was accepted and the recommendations adopted.

REPORT OF THE TREASURER

CURRENT FUNDS

RECEIPTS

Balance, December 31, 1929, (See Annals, XXIII, p 202)	\$2,510 02
From Annual Dues of Members to December 20, 1930	2,770 30
Received from T. D. A. Cockerell for Zoological Record Fund	5 00
Received from Annals	1,337 79
Received from Three Life Memberships	150 00
Interest on Liberty Bonds	15 52
Interest on Savings Account to December 31, 1930	213 28
Total	<hr/> \$7,001 91

EXPENDITURES

Telegrams, etc	\$ 2 69
Refunds for Excess Payments	2 00
Zoological Record	30 25
Lafayette Printing Co. Letterheads	8 00
Haywood Publishing Co., Filing Equipment	6 75
Spahr and Glenn Co., Printing of Annals for December, 1929, March, June and September, 1930	3,793 64
Clerical Service	53 67
Stamps and Stamped Envelopes	49 50
J. C. Moore Co., for Account Book Forms	3 22
Spahr and Glenn Co., Envelopes	6 25
Lafayette Printing Co., Nomination Blanks and Announcements	34 00
Lafayette Printing Co., Envelopes and Dues Cards	11 25
Lafayette Printing Co., Programs and enclosures	24 50
Reimbursement on Returned Checks	6 00
Exchange on Checks	4 80
	<hr/> \$4,036 52
Transferred to Permanent Fund—3 Life Memberships	150 00
Transferred to Permanent Fund—Interest	228 80
Total	<hr/> \$4,415 32
Balance in Bank	2,586 69
Total	<hr/> \$7,002 01

LIABILITIES

The Society owes the publishers for the December, 1930, Annals and a few miscellaneous expenses, and \$1,344 00 of the above cash receipts are 1931 dues

PERMANENT FUND

Liberty Bonds, (Annals XXIII, p 202)	\$ 350 00
In Purdue State Bank, (Annals XXII, p 202)	2,039 89
Three Life Memberships	150 00
Interest on Savings and Liberty Bonds	228 80
Total	<hr/> \$2,768 69

RESOURCES

Liberty Bonds	\$ 350 00
Savings Account, Purdue State Bank	3,700 24
Balance in Checking Account, Purdue State Bank	1,305 14
Total	<hr/> \$5,355 38

Respectfully submitted,

J. J. DAVIS, *Treasurer*

On motion the Treasurer's Report was accepted, subject to the approval of the Auditing Committee.

REPORT OF THE MANAGING EDITOR OF THE ANNALS.

I wish to report that the *Annals* has had the best year of its existence in the variety and quality of the articles submitted, in the quality of its illustrations and in the amount of material published. Much of the text was put into ten-point type in order to get more articles into the limited space. For the first time the annual volume has exceeded 800 pages. Probably the volume for 1931 will be as large. The help of a grant of \$500.00 from the National Academy of Science should be noted. Enough material is on hand for the March, 1931, number, which is now in the hands of the printer and some material for the June number.

I wish to thank Professor Osborn for continued interest and advice and for aid during the summer when the Editor is out. I wish to speak my appreciation of the printers, The Spahr and Glenn Company, and of Mrs. Elizabeth A. Davis, who has kept books that balance.

The financial summary follows:

RECEIPTS.

Non-member Subscriptions.....	\$ 575.77
From Sale of Back Volumes, Numbers and Reprints.....	716.47
From Engravings.....	537.15
From National Academy of Science.....	500.00
From Other Irregular Items.....	24.00
Total.....	<u>\$2,353.39</u>

DISBURSEMENTS.

Mailing Charges, Postage and Wrappers.....	\$ 114.36
Stenographic Service.....	268.66
Moving <i>Annals</i> stores to New Quarters.....	34.50
Engraving Bills.....	472.63
Incidentals.....	21.65
Check Returned.....	11.80
Reprints for Tropical Research Foundation.....	78.00
Membership Fees Passed on to J. J. Davis.....	14.00
Two Checks to J. J. Davis, Treasurer.....	1,337.79
Total.....	<u>\$2,353.39</u>

Vouchers are submitted herewith.

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor*.

On motion this Report was accepted, subject to the approval of the Auditing Committee.

No report was received from the Editor of the Thomas Say Foundation but the Treasurer, J. J. Davis, explained that a manuscript, intended for Volume 3, had been submitted to printers for estimates and the Committee hoped to be in a position to go ahead with publication early in 1931:

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

FOR THE YEAR 1930

RECEIPTS

Balance on hand January 1, 1930, (See Annals XVIII, p 206)	\$ 33 64
Interest on Savings Account to January 30, 1930	1 90
Received from sale of Volumes I and II	66 45
Received as Donations to Publication Fund	
C F Adams	\$10 00
Wm T Davis	10 00
Henry Bird	17 00
Franklin Sherman	5 00
J M Aldrich	20 00
H E Ewing	5 00
Total	67 00
Received as Loan—J C Bradley	10 00
Received for Future Volumes	
C W Johnson	\$10 00
E P Felt	5 00
Franklin Sherman	5 00
W A Riley	10 00
Total	30 00
Received from Heckcher Fund of Cornell University for publication of Volume 3	700 00
Total Receipts	\$908 99

EXPENDITURES

Postage on Mailed Volumes	\$ 2 35
Interest on Loan	19 50
	\$ 21 85
Balance in Purdue Bank	887 14
	\$908 99

There is a balance due on loan to pay for printing Volume 2, of \$325 00

Respectfully submitted,

J J DAVIS, *Treasurer*

On motion the Report was accepted, subject to the approval of the Auditing Committee

REPORT OF THE AUDITING COMMITTEE

1 That we have examined the accounts of the Treasurer of the Society, the Managing Editor of the Annals and the Treasurer of the Thomas Say Foundation and find the items given to be correct and properly balanced

2 To save the time of the Secretary-Treasurer and other members during the busy Convocation Week, we suggest that the Auditing Committee be appointed well in advance of the meeting and the work of auditing completed before the meetings begin

3 That the Auditing Committee be authorized to employ the services of a certified public accountant if they so desire

Respectfully submitted,

C L METCALF, *Chairman*,
T H FRISON

(The third member of the committee, C R Crosby, was not present at the meetings)

On motion the Report of the Auditing Committee was accepted and the recommendations adopted.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

Resolved, That the Secretary be instructed to convey to the authorities of the Case School of Applied Science and Western Reserve University, the gratitude of the Entomological Society of America for the accommodations they have furnished for the sessions just ending.

Resolved, That we express our great appreciation to the Director and Trustees of the Cleveland Museum of Natural History for the excellent facilities provided for the Annual Public Address.

Be it further Resolved, That thanks be extended to Prof. J. S. Houser, as Chairman of the Arrangements Committee, and to Mr. J. C. Pallister, of the Cleveland Museum of Natural History, for their efficient work in providing facilities for the meetings.

Respectfully submitted,

O. A. JOHANNSEN, *Chairman*,
A. F. SATTERTHWAIT,
W. V. BALDUF.

By vote of the Society, the Report of the Resolutions Committee was accepted.

Dr. F. E. Lutz reported briefly on the Division of Biology and Agriculture of the National Research Council.

REPORT OF THE NOMINATIONS COMMITTEE.

The Nominating Committee beg to report the following names as nominees for the respective offices for the year 1931:

President—J. W. FOLSOM.

First Vice-President—J. M. SWAINE.

Second Vice-President—HAROLD MORRISON.

Secretary-Treasurer—J. J. DAVIS.

Additional Members of the Executive Committee—For the term expiring 1933—R. C. OSBURN and W. T. M. FORBES.

Councillors to the American Association for the Advancement of Science—P. P. CALVERT and W. E. BRITTON.

National Museum Committee—C. W. JOHNSON and E. C. VANDYKE.

Respectfully submitted,

C. T. BRUES, *Chairman*,
FRANK E. LUTZ,
ARTHUR GIBSON.

On motion the report was accepted and Vice-President Snodgrass was instructed to cast a ballot for the election of the persons nominated. This being done, they were declared elected.

The Committee on Insect Collections reported as follows:

REPORT OF THE COMMITTEE ON
INSECT COLLECTIONS.

In presenting the following statements concerning the progress of the insect collections it may be stated that we have included reference to some private collections which may have a special value to entomological workers and we would call attention to the desirability of having information from the different entomological centers as to their willingness and facilities for giving identification in the different groups of insects.

Some of our members feel that there should be a greater recognition of the value of this kind of service and that some kind of compensation should be expected, especially when there is no equivalent return for the service requested. We are confronted with the fact that frequent demands are made upon specialists for service requiring much time as well as technical knowledge and with little or no return for the service.

Perhaps the most notable occurrence for the year has been the acquiring of the Barnes Collection of Lepidoptera for the U. S. National Museum. The contents of this collection is referred to in the report from the Museum but it deserves special mention since it is undoubtedly one of the very valuable collections to be found in this group and, moreover, is of distinct interest to our society because the acquisition by the Museum was no doubt facilitated by active support from a number of the society members. We may also feel gratified that special curator service for the collections in Hemiptera has been provided.

On the whole it appears that our insect collections are making substantial progress and becoming more and more prepared to serve entomological workers throughout the country.

It may be added that requests for information were sent to a number of public and semi-private or private collections which have not as yet been reported and it seems desirable to continue the requests for such information and the Committee will welcome statements from any organization which may have been overlooked.

U. S. National Museum, Washington, D. C. I am able to report that the Barnes Collection of Lepidoptera has come to the National Museum, through an appropriation made by Congress. This collection contains in the named series 1136 drawers with about 150,000 specimens; about 1000 species are represented by types and 800 more by cotypes and paratypes. There were about 4000 species represented by specimens that have been compared with types in American and foreign museums, and are so labeled. There are many microscopic slides of genitalia, etc. In addition to the determined part of the collection, there are about 300,000 other specimens more or less classified. The Brooklyn Museum through a change of policy has decided to devote itself to popular exhibits, and its general collection of insects was deposited in this Museum, including about 37,000 specimens and 477 types of species. We have also received through the year about 50,000 specimens of Chinese insects from David C. Graham of Suifu, Szechwan, China; these were all undetermined.

—J. M. ALDRICH, Associate Curator, Division of Insects.

American Museum of Natural History, New York City. I have checked up our accessions for the past year and find that the American Museum collection of insects, through donations and collections made by our staff, has been enriched by about 16,000 specimens. The larger donations include 1200 North American beetles from Mr. H. G. Barber and about 1000 miscellaneous North American insects from Mr. E. L. Bell. A number of smaller donations have been received from different parts of the globe. In these, the West Indies are represented by more than 1200 miscellaneous insects and Tropical Africa by about 1000 specimens, most of which are Lepidoptera. The principal collections made by the Museum staff are about 6000 specimens, mostly Diptera, collected by Mr. C. H. Curran in the vicinity of Cold Spring Harbor, Long Island and Ontario, Canada. Several hundred miscellaneous insects, including a number from the thermal springs, were collected at Yellowstone, Wyoming by Dr. F. E. Lutz.

—A. J. MUTCHLER, Associate Curator.

Museum of Comparative Zoology. During the past year the following collections were received: The Chilean Hymenoptera of the late Paul Herbst, about 8000 specimens, partly named; about 1000 specimens from Hawaii collected by Dr. Wheeler; about 2000 obtained by Prof. C. W. Dodge in Costa Rica; over 2000 taken by Arthur Loveridge in Tanganyika Terri and Rhodesia; about 6000 insects from Southern Mindanao, Philippine Islands, collected by C. S. Clagg; the Lepidoptera of the late C. J. Paine, largely New England, but many western and exotica, largely named, about 10 to 12,000 specimens; the Geometridæ of the late Louis Swett, over 1000 specimens, mostly named and about 40 types; about 5000 specimens collected in the mountains of North Carolina and Tennessee by a Museum Expedition consisting of the Curator, Mr. Carpenter, and Mr. Darlington; the general collection of the Bussey Institution, mostly Lepidoptera, and with the types of a few aberrations by Reiff; about 1000 insects taken in Wyoming and South Dakota by Mr. G. Fairchild; over 1000 (mostly Hymenoptera) taken in Arizona in 1917 by Dr. Bequaert; others taken by Dr. Bequaert in Yucatan, and by Mr. Stadelmann in Honduras. Over 1000 spiders given by Mr. Emerton, and about as many from Mr. Creighton in the Southern States. These with various smaller lots bring the additions to fully 45,000 specimens.—NATHAN BANKS.

Boston Society of Natural History. Dr. R. Heber Howe has recently presented to the Society his entire collection of New England Odonata comprising 152 species, represented by over 1000 specimens, together with over 500 specimens of their nymphs, both dry and in alcohol. It is by far one of the finest local collections of this order ever brought together. The value of the collection is greatly enhanced by its being the basis of Dr. Howe's valuable *Manual of the Odonata of New England*, published in six parts (March, 1917, to March, 1920) and comprising 102 pages with illustrations of all the species. A supplement was published in March, 1921, adding eight species, making the total number of species for New England, 164. In May, 1921, Dr. Howe published an interesting paper in the *Proceedings* on "The Distribution of New England Odonata." Later he extended his *Manual* to cover the nymphs publishing 3 parts (December, 1921, to November, 1927) comprising 47 pages with illustrations, keys and figures. His work has added much to our knowledge of the dragon flies of this region and the collection is a most valuable addition to the Society's collection.—C. W. JOHNSON.

Utah Experiment Station. The insect collection here consists principally of insects collected within the boundaries of the state. Most of the collecting has been done in connection with work on various projects. During the past two years, 2000 insects have been added to the collection, in connection with the alfalfa insect studies. Several thousand insects have been pinned, from the large amount of material collected in connection with beet leafhopper and miscellaneous insect investigations.—G. F. KNOWLTON.

The University of Nebraska. As in 1929, the insect collection here received considerable attention in the matter of rearrangement of the collection. Certain groups have been entirely gone over and much new material incorporated. Mr. E. F. Powell has completely named and rearranged the *Chrysomelini* and Professor D. B. Whelan is doing the same for the *Halticina* in the beetle family Chrysomelidæ. Mr. R. H. Nelson named and arranged the Culicidæ in the collection. Mr. O. S. Bare added extensively to the Formicoidea in the collection during 1930. Mr. Raymond Roberts, having named and rearranged the collection of Vespoidea in 1929 and previously, in 1930 worked intensively on the Scoliidæ, naming and incorporating material from Colorado, Oregon, California and other western states.—MYRON H. SWENK, Chairman, Department of Entomology.

Purdue University. I am not sure that I have ever given you a statement of specimens in the Purdue University Entomological Collection. My estimate is as follows: Hymenoptera, 2000, Diptera, 1000, Lepidoptera, 6000, Coleoptera, 35,000, Hemiptera, 2500, Homoptera, 3500, Odonata, 1500, Orthoptera, 2000, Other Orders, 1000, Total, 54,500. In addition, Dr. C. F. Adams has recently donated his collection of Diptera of about 12,000 specimens.—J. J. DAVIS.

Massachusetts Agricultural College. I may say, as regards the growth of the collection at this college, that only normal progress has been made. This has been developed chiefly in the order Coleoptera through the continued kindly

interest of Mr. C. A. Frost. The curator of the collections has continued the rearrangement of the Coleoptera, and about one-half of the families of this order are now in their permanent cases.—CHARLES P. ALEXANDER.

Also, Doctor Alexander says concerning his personal collection, "To the date of November 1st, my collection of crane-flies includes 4,770 species, of which 3,585 species are represented by type material either holotype, allotype, or paratype. This collection includes the families Tanyderidæ, Ptychopteridæ, Trichoceridæ, and Tipulidæ."

Clemson Agricultural College, Clemson, S. C. Developing a general and economic collection, chiefly of state fauna; in Schmitt boxes and glass-topped cases. About 350 boxes and cages now in use. Following groups best represented: Acrididæ, larger Heteroptera, Cicindelidæ, Carabidæ and Cerambycidæ. A card-catalogue record of state fauna is maintained.—FRANKLIN SHERMAN, JR.

The entomological collection of the *Brigham Young University* consists of over 75,000 pinned specimens, and 500 specimens mounted upon slides. The pinned insects are placed in three hundred trays, 18 x 19 inches in size, two inches deep and 150 Schmitt boxes. The specimens are pinned in unit boxes. The Lepidoptera collection is a very complete one of Utah and the Great Basin region. It contains over 600 named species and 10,000 specimens. It is made up of the famous Tom Spalding collection and the Chester Van Buren collection of South American butterflies. The Coleoptera collection contains over 5000 determined species and 30,000 specimens. It contains a very complete collection of weevils, 300 species from the Blatchley collection. It is the aim of the University to make this collection a very complete one of the species of the Great Basin region.—VASCO M. TANNER.

Illinois State Natural History Survey, Urbana, Illinois: During the past year the Survey collection of insects has continued to grow due to collecting in various localities throughout the state by members of the staff. Special attention was devoted last summer to completing a survey of the plant lice of Illinois with the result that 1,500 slides were added, bringing the total number of slides of plant lice to approximately 12,000. A survey of the plant bugs of the state was started with the result that some 2,000 specimens were added to the already extensive series of these insects in our collection. This plant bug survey will be continued for several summers. Another group of insects receiving special attention was the stoneflies, or Plecoptera, and our collection was increased by about 500 specimens preserved in fluid. About 2,000 specimens of insects, belonging to various groups, were added to the collection incidental to work on special projects. The Survey received by donation another series of Cynipidæ, including galls and some types, from Dr. A. C. Kinsey, besides a few other specimens and types in diverse groups of insects.—THEODORE H. FRISON.

Experiment Station, Hawaiian Sugar Planters Association. We have no new or important features to report on since the report that was published on page 205 of *Ann. Ent. Soc. America*, 23, No. 1, 1930. A line has been omitted, which leaves out reference to our large collection of Fulgoroidea which was worked up and arranged by Dr. Muir. In line 30, p. 205, following "worked up," it should have read, "much of the Fulgoroidea, however, have been worked up and are arranged in a large cabinet. There are several hundred types."—O. H. SWEZEY.

Kansas State Agricultural College, Manhattan, Kansas. "We would mention first the general collecting trip made by Dr. R. H. Painter and Mr. T. F. Winburn, in the southwestern part of the United States in which somewhere between 5,000 and 6,000 specimens in the various orders were collected. Of particular significance is the addition of Bombyliids which includes approximately 100 species distributed in 25 genera, several of which are very rare and heretofore known only by type. Mr. Hobart Smith, a senior student, also made a trip in the Southwest and collected approximately 1,000 specimens, consisting largely of Coleoptera. A collection of six Schmidt boxes of the more common insects of Haiti was brought to the department by the writer during the war. An addition of approximately 1,500 specimens of Homoptera was made to the collection by Prof. D. A. Wilber in the course of the season's collecting. The alcoholic collection was worked over during the year and there was installed the method of hanging the vials on

an upright woven wire frame. This method has much to commend it. Mention was not made in last year's report of the purchase of three steel cabinets holding 75 Schmidt boxes each for the Knaus collection of Coleoptera, and of three steel cabinets holding 50 insect drawers for the department's permanent collection. These cabinets will enable us to keep our collection in better condition than ever before. Members of the department are willing to make determinations in the family Bombyliidae and North American Neuroptera.—ROGER C. SMITH.

Indiana University. In addition to the general collections for teaching purposes, we continue to build up our collection of *Cynipidae*. In this single family, including both gall wasps and galls, we have something over a million specimens, perhaps 350,000 of these being insects. The yearly increment averages 25,000 bred insects and three times that many galls. During the past year we have bred over 100,000 insects, about 75,000 of which represent a single species whose evolutionary status we have under especial investigation. The collection is preserved in pest-proof equipment in a fire-proof building. We can offer complete facilities to students who may care to study our material.—ALFRED C. KINSEY.

HERBERT OSBORN, *Chairman*,
JAS. G. NEEDHAM,
CHAS. W. JOHNSON,
NATHAN BANKS,
EDW. C. VAN DYKE.

J. Chester Bradley moved that a committee of three be appointed by the President to aid in making arrangements for the International Congress of Entomology to be held in Paris in 1932. Motion seconded and carried.

No report received from the Historical Committee.

C. H. Curran moved that the Society be authorized to loan to the Thomas Say Foundation a sum up to \$500.00, from the Permanent Fund in order to finance the publication of volume 3 of the Foundation, the final approval of the loan subject to the approval of the Executive Committee. Motion seconded and carried.

The Secretary read a letter from C. W. Stiles calling attention to an amendment to the Law of Priority in nomenclature, which becomes effective January 1, 1931. The amendment reads as follows:

ARTICLE 25.—

But no generic names nor specific name published (as new) after December 31, 1930, shall have any status of availability (hence also of validity) under the Rules, unless and until it is published either

1. with a summary of characters (seu diagnosis; seu definition; seu condensed description) which differentiate or distinguish the genus or the species from other genera or species;
2. or with a definite bibliographic reference to such summary of characters (seu diagnosis; seu definition; seu condensed description). And further
3. in case of a generic name, with the definite unambiguous designation of the type species (seu genotype; seu autogenotype; seu orthotype).

Meeting adjourned.

The Annual Entomologists' Dinner, attended by 225 entomologists, was held in Hayden Hall of Western Reserve University, Wednesday evening, December 31.

Respectfully submitted,

J. J. DAVIS, *Secretary*.

BOOK NOTICES.

RECENT ADVANCES IN ENTOMOLOGY. By A. D. IMMS.
Pages I-VIII and 1-374, 84 figures. Published by P. Blakiston's
Son and Company, Inc., Philadelphia, 1931.

This volume is remarkable in the care given to the selection of material, in the broad field covered and in the grasp of the essential problems in each field. "It attempts to review and discuss certain aspects of the subject along which recent advances have been fertile in new facts and ideas." In fifteen chapters it covers the problems and recent advances in Morphology, chapters I and II, Metamorphosis, III, Palaeontology, IV, Sense Organs and Reflex Behavior, V and VI, Colocation, VII, Ecology, VIII-XI, Parasitism, XII and XIII, and Biological Control, XIV and XV.

There is an index to authors and a very complete general index which makes it very usable. It is a book that every entomologist in the pure science will want and every man in applied entomology must have. Incidentally it shows the broad grasp of the author on all fields of entomology.—C. H. KENNEDY.

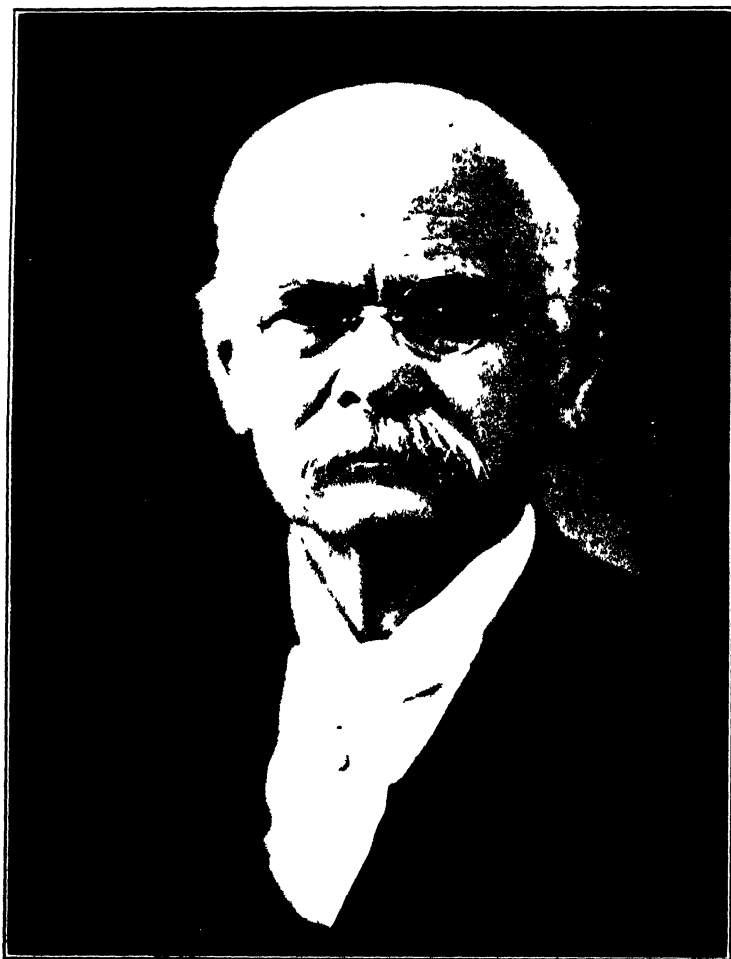
HISTOLOGICAL AND ILLUSTRATIVE METHODS FOR ENTOMOLOGISTS. By H. ELTRINGHAM, F. R. S., F. E. S., F. Z. S., with a Chapter on mounting whole insects by H. BRITTEN, F. E. S. Pages I-XII and 1-139, 21 figures. Published by Oxford University Press.

This book is of special interest because it outlines the methods used by Eltringham in his own exacting work on the histology of obscure organs in insects. The long series of his papers of a histological nature that have appeared in the Transactions of the Entomological Society of London have made all morphologists wish for a detailed account of his technique. This the volume gives. There are nine unnumbered chapters covering such subjects as Apparatus, Reagents, Materials; Wings, Scales; Genitalia; Fixing, Embedding, Section-cutting; Staining; Preparation of Whole Small Insects (by Britten); Drawings; Lantern Slides and Photographs; Models. The book is thoroughly indexed and is very usable because of the numerous black-face headings.

—C. H. KENNEDY.

A MANUAL OF THE GENERA OF BEETLES OF AMERICA, NORTH OF MEXICO. Keys for the determination of the families, subfamilies, tribes and genera of Coleoptera with a systematic list of the genera and higher groups. By J. CHESTER BRADLEY. Pages I–XII and 1–306. Lithoprinted (Mimeograph). Published by Daw, Illston & Co., Ithaca, New York.

This is a mimeograph publication of the keys to the genera of Coleoptera prepared by Bradley for his classes. It is a compilation from the latest and best keys and appears to be the first key covering America North of Mexico since LeConte and Horn in 1883. It is to be used with Leng's catalogue which is a key to the literature of species. In parts of the work alternate keys from two or more sources are given. It is dedicated to W. S. Blatchley and is thoroughly indexed to genera and all higher groups. The systematic arrangement follows Leng's catalogue. It is lithoprinted by Edwards Brothers of Ann Arbor, a new process using metal plates and producing very clear and clean text.—C. H. KENNEDY.



JOHN HENRY COMSTOCK

ANNALS OF The Entomological Society of America

Volume XXIV

JUNE, 1931

Number 2

PROFESSOR JOHN HENRY COMSTOCK*

February 24, 1849 — March 20, 1931

Professor Comstock was chairman of the committee on Organization of the Entomological Society of America; and at its first official meeting in New York City on December 28, 1906, he was elected its first President.

If some of us still cherish the philosophy that a struggle for existence does act as a developmental factor, perhaps we shall be pardoned for believing that the early struggles of Professor John Henry Comstock for an education did develop in him some of those fit qualities that later contributed to his scientific achievements. Notwithstanding, something of his character must certainly be attributed to his parental inheritance. His mother, Susan Allen, was reputed to be of the family of Ethan Allen. Evidently it was she who transmitted to her son the determination and tenacity of purpose which characterized his labors on the problems he undertook to solve.

His father, Ebenezer Comstock, was a teacher who had spent two years at Williams College in Massachusetts. Apparently the father was a man of idealism and imagination. At any rate, he left the mother and the infant in Janesville, Wisconsin, where the latter had been born, and joined a party of "forty-niners" in search of the alluring, romantic metal, gold. Unfortunately his party became infected with cholera and he early succumbed to an attack of the disease. Thus the mother was left alone with a mortgaged farm which soon fell into unscrupulous hands and she lost it all. This accumulation of untoward events forced her to return with her son to her native state, New York. Here the struggle continued

*This account of Professor Comstock's life was written at the special request of the Editorial Board.

until finally she was forced to place the child in a public institution. Later, after passing short periods in the homes of different relatives, the boy accidentally found a genuine welcome to the home of Captain Lewis Turner, a retired sailor and a rigorously just but hospitable man.

"Here he was to have his board and clothes and three months schooling in the winter in return for which he was to do whatever work Captain Turner wished." The bargain was rigidly adhered to by both participants, but the boy was treated justly and kindly and for the first time within his memory he felt at home and happy. The three sons of Captain Turner were sailors on the Great Lakes and naturally when the boy Comstock reached the age of 16, he too became a sailor. This gave him an opportunity to earn enough money during the summer to defray the expense of attending school during the entire winter.

He had become interested in botany and had begun to search for a book which would give him some information regarding lichens and mosses. While his boat, on one of its cruises, was anchored in the port of Buffalo, he visited the shop of a book dealer in search of the desired work on Cryptogams. Instead of finding the botany he ran across that entomological classic, Harris' "Insects Injurious to Vegetation." The book with its fine plates interested him intensely and although he lacked the funds he determined to own it. He went to the Captain for an advance from his wages, obtained the necessary amount and the next day returned and purchased the precious book. The entry on the fly-leaf of this copy in Professor Comstock's own hand, made November 19, 1876, is as follows: "I purchased this book for ten dollars in Buffalo, N. Y., July 2, 1870. I think it was the first entomological work I ever saw. Before seeing it I had never given entomology a serious thought; from the time that I bought it I felt that I should like to make the study of insects my life's work." Undoubtedly this fortuitous event gave to entomology one of its masters.

By working summers and going to school winters he was ready at 20 years of age to enter that new institution, Cornell University, of which he had heard good report. He entered the University with the opening of its second year, in the fall of 1869. He literally helped to build the institution, for he

labored with his hands in the construction of McGraw Hall, the building in which he was later to become an instructor. The manner of his becoming an instructor is interesting. His knowledge of insects had already given him a reputation among his classmates; and in the spring of 1872, thirteen of them, including David Starr Jordan, petitioned the faculty to allow Comstock to give them a course in entomology. Thus he became an assistant, later an instructor, an assistant professor in 1876, and Professor of Entomology and Invertebrate Zoology in 1882, which position he held until his retirement in 1914, at the age of 65.

Although he entered Cornell in 1869, he became ill and had to defer his college education for another year. Entering again in the fall of 1870, this time to stay, he was graduated in 1874. During these early years he had been struggling by himself to gain a knowledge of entomology. But now that Agassiz had brought the European savant, Dr. H. A. Hagen, to Cambridge, Comstock while yet an undergraduate, embraced the opportunity to study with the latter during the summer of 1872. Professor Comstock has told the writer of his experience as a student with Dr. Hagen. The latter, a large man, would enter the laboratory in the morning, remove his coat, take a comfortable chair at a table covered with insect cases, light his large German pipe and say to Comstock, "Kom here und I vill dell you some dings vat I know aboot insects." To the young man filled with zeal for knowledge of his chosen field of work it was an inspiring and memorable summer.

During the year 1874-'75, Comstock spent some time in graduate work at Yale University giving particular attention to general invertebrate zoology. In 1888-'89 he was a student in the laboratory of Leuckart in Leipzig. His contact with Leuckart and with Leuckart's students exerted a most stimulating effect on his early career which lasted throughout his life. He returned to his work at Cornell with great enthusiasm and vigorous activity.

During the summer of 1878, C. V. Riley then chief entomologist of the United States Department of Agriculture, employed Comstock as temporary field agent. He was sent to Alabama to make a study of the cotton-leaf "worm" (*A. argillacea*). This was really his first extended work in the field of economic entomology. In the following April, 1879,

Riley resigned and Comstock was appointed to succeed him. For the following two years, Comstock, L. O. Howard, Theodor Pergande, and Mrs. Comstock with George Marx as illustrator, worked together in Washington harmoniously and most enthusiastically. It was during this period that Comstock made his basic studies on the Coccidæ. His reports for the year 1879 and the year 1880, together with his report on cotton insects, were also among the fruits of those two years. Soon after his return to Cornell University in 1881 he published his second report on scale insects. His interest in economic entomology continued through all of his active years.

His work as an investigator began to express itself in published papers as early as 1872. His ability and enthusiasm in research grew with the years. This is indicated by his papers on the Coccidæ (1880, 1883), his essay on The Descent of the Lepidoptera (1892), and on Evolution and Taxonomy (1893) and by his papers in collaboration with J. G. Needham on the wings of insects (1899). Subsequent papers embodying the results of researches on spiders appeared regularly during his later years. These culminated in the publication of "The Spider Book," (1912). Following his retirement in 1914 he devoted the remaining years to the rounding out of his life's work. The results of his long years of research on the wings of insects were finally brought together in the form of a book, "The Wings of Insects," (1918), probably his chief contribution of pure research. His last years were devoted to the writing of his final work, "An Introduction to Entomology." Happily this was completed before his last illness. Professor Comstock never engaged in controversy nor did he criticise the work of others. He did his own work as well as he knew how and with faith in it, passed over adverse criticism of it in silence. On the other hand, no one was franker to acknowledge a mistake than he, for accuracy was almost a fetish with him. Moreover, he never appropriated the work of others. Speaking of this just practice of his, Dr. Howard says, "Comstock was a very fair and honest man, as his subsequent career has shown."

Professor Comstock was one of the earliest teachers of entomology in the United States; and his ideals and standards have exerted a profound influence on the teaching of entomology in this country. His early struggles in self-education undoubtedly developed a mental tendency to obtain a clear, precise,

logical arrangement in his own mind of the problem in which he was interested. As a result, his lectures were models of simplicity, clearness, and conciseness. This logical quality of mind, together with his infectious enthusiasm and his personal interest in his students, made him a great teacher. Moreover this characteristic, together with his experience as a teacher, contributed to his success as a writer of text-books. His work as a teacher and organizer of the Department of Entomology at Cornell led David Starr Jordan, of Leland Stanford Jr. University, to invite him to organize a similar department at that University. Accordingly his winter vacations from 1891 to 1900 were spent at Stanford where, with Dr. Vernon L. Kellogg, he organized and conducted the work in entomology on much the same basis as at Cornell.

The summer season at Ithaca has always been an ideal time for the study of insect life. The diversity of topography in the Finger Lakes region together with the accompanying variations in climatic features provides a wide variety of flora with a great diversity of insect fauna. During the summers for many years, Professor Comstock offered instruction in entomology at Cornell for a term of ten weeks. The usual daily procedure was to gather at 8 a. m. in the lecture room and listen to a clear, concise account by Professor Comstock of the habits and characteristics of a group of insect forms. The lectures followed the order and arrangement of the material as outlined in the well-known "Manual for the Study of Insects." At the close of the lecture, everyone equipped with collecting apparatus, went into the field for the remaining part of the forenoon. In the afternoon the collected specimens were mounted, studied and determined as far as possible. Thus each student became acquainted with a wide range of forms, with their habitats, often with their food plants and finally with the literature treating of them. It was during these summer terms that many of Professor Comstock's older, more mature students came to Ithaca to pursue advanced work in entomology. It has seemed to the writer that those summer seasons of laboratory and field instruction offered nearly ideal opportunities for acquiring a basic knowledge of insect life. It was during the latter part of this period of Professor Comstock's career that he became more deeply interested in morphology and began the development of that phase of entomology

in his laboratories. Professor Comstock never stagnated in his own growth or in the growth of his department. During the years of his labors he taught entomology to more than 5,000 students. Certainly all of these especially interested in entomology participated in the hospitality of the Comstock home. Indeed, Professor and Mrs. Comstock always maintained an open house for students of the University; and the cordial warmth of sympathy and hospitality enjoyed in their home will remain a precious memory to scores of men and women all over the world.

Professor Comstock was so absorbed in his work as teacher and investigator that he gave little time or thought to the more public activities of scientific societies and organizations. His devotion to his students, his zeal to advance the science of entomology, his loyalty to Cornell University and his ardor to enhance its prestige, animated his life with a great, single, unselfish purpose. His quiet, effective achievements have received wide recognition. On his retirement his students presented a memorial to him in the form of a generous fund, the income from which is devoted to the upbuilding of a "Comstock Memorial Library" of entomology. He was an honorary member of the Entomological Society of London; an honorary member of the Entomological Society of the Netherlands; a member of the Entomological Society of France; of the American Philosophical Society and of the California Academy of Sciences. He was made an honorary member of the Fourth International Congress of Entomology. His books are known and used the world over. Goldwin Smith, an early teacher of history at Cornell, inspired us with the moral principle that above everything is humanity. Accepting this, we may well believe that Professor Comstock's greatest memorial consists of that splendid body of men and women who have gone out under his training and inspiration to hand on the truth as he tried to teach it.

On the night of Thursday, March 19, 1931, he suffered a final collapse and during the early morning of Friday, March 20, he succumbed. On the following Tuesday his ashes were placed beside those of Mrs. Comstock in Lakeview Cemetery on a beautiful site overlooking the valley and Lake Cayuga. Thus he lived and completed a life devoted to his science, to his students and friends, to his beloved Alma Mater and to an unselfish effort to promote useful and cultural knowledge.

GLENN W. HERRICK.

A STUDY OF THE GENUS NEMOBIUS. (ORTHOPTERA: GRYLLIDÆ).*

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The genus *Nemobius* is one of the largest of the family Gryllidæ and has world-wide distribution. The most comprehensive work on the American species of the genus is a revision by Hebard (1) which cleared up the synonymy and made it possible to identify the species with greater assurance. His classification is based largely on the characters of the ovipositor, for few reliable male characters were known at that time.

In studying the mating habits of these crickets, the writer discovered that the concealed genital armatures of the males which are protruded while mating provide excellent characters for the identification of most of the species. A study of their structure throws further light on the relationship of our native species. While they do not clearly differentiate races or some closely related species, they make it possible to identify several species with greater certainty with the male sex than with the female.

In order to point out some of the important male characters it is necessary to describe the genitalia and originate some terms for the rigid parts of a protrusible organ that is described more fully in connection with the mating habits. When not in use this organ lies in a horizontal position above and concealed by the subgenital plate. In recently killed specimens, it can easily be pulled out by an insect pin with a slightly bent point, which can be hooked on to the basal supporting structure. On drying, there is a tendency for the organ to pull back into the body unless the attached membrane has been greatly stretched or ruptured. This does not apply to specimens which have been previously dried and relaxed.

The entire structure is roughly cylindrical in shape. The basal part of the dorsal† face, is the main supporting structure.

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†All terms of orientation in the discussion of this structure apply to the horizontal position assumed when withdrawn into the body.

The attached lateral pieces may be termed claspers since they are provided with muscles that draw the ventral edges together. The ventral face is hollowed to form a longitudinal

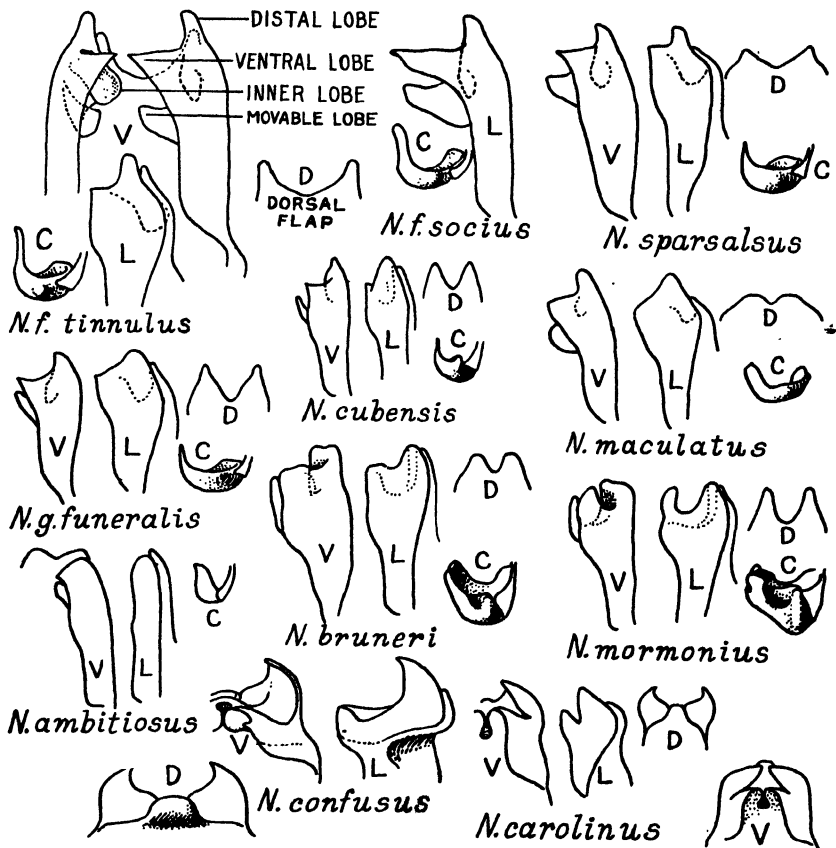


FIG. 1. Male genitalia: right claspers and dorsal flaps. V, Ventral view. L, Lateral view. C, Caudal view. Ventral view of *tinnulus* is of both claspers from a slightly lateral position to show inner lobe of the left. Inner lobes in other ventral and lateral views, indicated by dotted lines.

groove between the claspers. At the distal extremity each clasper is hollowed out on the mesal or internal face and in most of the species has a distal lobe, a ventral lobe which in some species is a sharp tooth, an inner lobe on the mesal face and a movable lobe which is rather loosely attached to the mesal surface, proximad to the inner lobe. The distal extension of

the main supporting structure on the dorsal side fills in the space between claspers on that side and may be called the dorsal flap. The outline of its distal margin furnishes important specific characters.

The ventral groove is provided with thick cuticle, which retains its shape, but between that and the bases of the claspers are areas of thin integument which collapse on drying. The extent to which the claspers are drawn together will affect their appearance and often the internal and movable lobes are hidden. For this reason the ventral and lateral views of the claspers shown in Fig. 1 are drawn from an arbitrary position as if the tips of the ventral lobes did not quite reach the median line although in many specimens they will be found to overlap considerably or may be widely separated.

RELATIONSHIP OF THE SPECIES

The characters of the male genitalia substantiate with few exceptions, Hebard's grouping of species found in the United States. No specimens were available for examination of *Nemobius carolinus brevicaudus* Bruner, *N. carolinus neomexicanus* Scudder and *N. eurynotus* Rehn & Hebard.

Those species having the disto-ventral spurs of the caudal tibiae equal in length; namely, *carolinus* Scudder and *confusus* Blatchley have a distinct type of male genitalia. The claspers are very short and are attached diagonally to the dorsal support. The distal lobe is hollowed on the mesal face and is claw-like in shape. The ventral lobe is also claw-shaped but attached to a fold of thin integument which meets the one on the opposite side forming a diaphragm in the ventral groove. This fold, apparently, takes the place of the movable lobe in the other species. The dorsal flap is reduced to a small, rounded, arched extension of the dorsal support.

Among the species having unequal disto-ventral spurs on the hind tibiae, *N. ambitosus* Scudder seems to stand in a class by itself. It has a unique feature which was called to the writer's attention by A. N. Caudell, of having a bald shining face. The bristles of the head are limited to the occiput, while in other species they reach as far as the median ocellus. The male claspers lack distinct distal and inner lobes, but have the usual form of movable lobe. The dorsal flap is long and has a very shallow median notch.

Of the remaining species, those having the longer and straighter ovipositors, namely, *fasciatus* (4 races), *griseus* (2 races), *sparsalsus* Fulton and *maculatus* Blatchley, have a common feature in the male sex in the shape of the inner lobe of the clasper which is difficult to see without dissection. This is flattened and concave on the mesal face; and extends dorso-cephalad beneath the dorsal flap. In *maculatus*, it is reduced to a small projection on dorsal edge of the clasper, and this species differs further in having blunt ventral lobes on the clasper, and a short rounded dorsal flap with a small rounded median notch.

The male genitalia of *N. griseus griseus* E. M. Walker and *N. grieseus funeralis* Hart are very much alike, and are characterized by the broadly rounded distal lobe of the clasper, when viewed from the side. The clasper of *sparsalsus* has a very broad base and short ventral lobe. The dorsal flap has a very shallow notch, and the lateral angles are not prolonged. The genitalia of the races of *fasciatus* are described under the discussion of that group.

Among the species with short ovipositors, *cubensis* Saussure, *palustris* Blatchley, *bruneri* Hebard and *mormonius* Scudder, the dorsal edge of the inner lobe of the clasper takes the form of a prominent longitudinal ridge on the mesal face, extending directly cephalad from the distal lobe. *Cubensis* and *palustris* have almost identical male genitalia. In specimens of *palustris* examined the dorsal edge of the inner lobe was more prominent and extended more nearly to the tip of the distal lobe than is shown in the ventral drawing of the clasper of *cubensis*. In both species the ventral lobe is very thin and sometimes bends inward on drying.

The male genitalia of *bruneri* and *mormonius* show similarities but are distinct enough not to be confused. Both have the movable lobes very narrow at the tips where they are parallel to the mesal edges of the ventral lobes. At the base the movable lobes are thin walled and extend across the mesal faces of claspers forming a diaphragm. In this they are supplemented by the cephalic end of the inner lobe of the clasper which curves sharply around to the ventral side and partly closes off the space between the two claspers, caudad to the basal portions of the movable lobes.

In *mormonius* the notch between the ventral lobe and the distal lobe is very deep, the inner lobe forms a large part of the above described diaphragm and the cephalic margin extends to the base of the ventral lobe. The dorsal flap has narrower lobes and a deeper notch than in *bruneri*. In *bruneri* the cephalic edge of the inner lobe is not prominent and it recurves almost to the apex of the ventral lobe.

It is evident that *mormonius* is a distinct species showing closest relationship to *bruneri* and not a geographical race of *cubensis* as formerly considered. My specimens from the Bright Angel Trail of the Grand Canyon, Arizona and two male specimens from Las Vegas, Nev. loaned by Hebard belong to the same species. The male allotype of *mormonius* designated by Hebard was from Las Vegas.* The designated type was from St. George, Utah. The two localities are only a little over a hundred miles apart and both in the Colorado basin so it is unlikely that the female would be a different species. The specimens examined have a pale face with a faint trace of a pattern similar to the dark pattern found in *bruneri*. There is a darker band across the occiput from eye to eye. This is present in *bruneri* but is broader and does not quite reach the eyes. The pronotum has a pattern similar to *bruneri* but with less contrast in the colors. The legs also lack conspicuous markings.

Two male specimens from Brownsville and Dickinson, Texas, loaned by Hebard as specimens of *mormonius* have the genitalia as in *bruneri* although the coloration is more like *mormonius*. The placement of these specimens involves the relative specific value of color characters as against the morphological characters of the male genitalia. I prefer to depend on the latter for in other species covering a wide geographical range there is little variation in their structure.

The determination of the geographical limits of *bruneri* and *mormonius* and the relationship of the two species will require a study of the male genitalia of a large number of specimens.† Hebard (1) pointed out the resemblance to *bruneri* of the Texas specimens he placed under *cubensis mormonius*. Further

*Since writing this paper the writer has examined specimens, loaned by Hebard, from localities ranging from Beauregard Co., La., to Brownsville and Del Rio, Texas, all of which were similar to the above mentioned Texas specimens in coloration and genital structures.

study may show that they comprise a geographical race of *bruneri* or that they are a connecting link between *bruneri* and *mormonius*.

THE RACES OF *N. FASCIATUS*

This species seems to be in the process of splitting up into races which are not well defined morphologically but are definite entities in nature. Three of the races have been recognized and named. The fourth has apparently escaped description as a new species or variety by earlier entomologists, while both typical *fasciatus* and the race *socius* are credited with more than one synonym. This is explained by the more secretive habits of the race, resulting in fewer specimens in collections. In order to give this race a name for further discussion of the problem it is here defined as a new subspecies.

*Nemobius fasciatus tinnulus** new subspecies. Type; male; Raleigh, N. C., September 16, 1928. Types to be deposited in the U. S. National Museum.

Nemobius fasciatus tinnulus subsp. nov.

A male was selected for the type because that sex presents more characters to distinguish it from the other races of *fasciatus*. It differs in the following features: dorsal field of tegmen relatively broader, (Fig. 2, A); in life the lateral margins of dorsal fields held nearly parallel; longitudinal or proximal portion of stridulatory vein forms nearly a right angle with the file; length of the file, as far as the perpendicular branch on the distal side (1.5 mm.) greater than the remaining portion of the lateral field (1.2 mm.); distal margin of dorsal field broadly rounded; length of exposed dorsal field 5.4 mm.; greatest width 2.9 mm. Allotype; female; same data as type.

Length of ovipositor as far as perpendicular portion of base on dorsal side, 7.5 mm.; length to extreme base on ventral side, 7.9 mm.; length of hind femur, 7.5 mm. Tip of ovipositor with 9 teeth on dorsal margin; toothed margin with a slight curvature, (Fig. 2, D). Color notes: By comparison with Ridgway's "Color Standards and Nomenclatures," the ground color of the head above the median ocellus is close to orange cinnamon; an obscure pattern between the upper portions of the eyes, snuff brown; face below ocellus kaiser brown; pronotum snuff brown, slightly darker on dorsal portions of lateral lobes, ventral portion of lateral lobes cinnamon buff; legs and ventral side of body with a ground color of cinnamon buff, but on the legs almost entirely obscured by buffy brown; on the hind femur the brown is in the form of numerous oblique dashes. In the male the sides and

*Tinnulus = Tinkling, clinking. So named because of the quality of the song.

dorsum of abdomen nearly entirely black. In the female, concealed portion black; exposed portion buffy brown with a rather broad black median stripe; sides with large black patterns on the cephalic portions of the segments; lateral portions of dorsum with two small black spots on each side near the caudal border of each segment.

The male tegmina are darkly infuscated over the areas shaded in the illustration, (Fig. 2, A). Paratypes selected; 1 male, 1 female, same data as type; 1 male, 2 females, Raleigh,

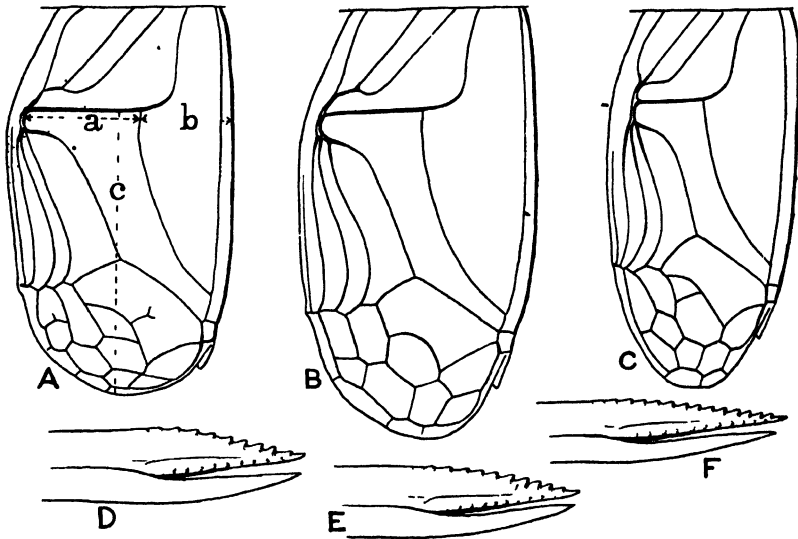


FIG. 2. Tips of ovipositors and male tegmina. A, *N. fasciatus tinnulus*, type. D, *N. fasciatus tinnulus*, allotype. B, E, *N. fasciatus fasciatus*, (Raleigh, N. C.). C, F, *N. fasciatus socius*, (Raleigh, N. C.).

October 8, 1928; 1 male, 1 female, Raleigh, October 15, 1930; 1 male, 1 female, Plymouth, N. C., October 25, 1928.

This woodland race was first observed at Mt. Pleasant, Iowa, where it attracted the writer's attention by its characteristic type of song. It was not found in any other part of Iowa. At that time it was regarded as a purely physiological race of *fasciatus* and its habits were commented on in an earlier publication (2). In North Carolina it is common in woods over a large part of the state. In addition to the localities represented by the paratypes, it has been taken in N. C. at Reidsville, in the north central portion and at Sparta and

Burnsville in the mountain regions. In the U. S. National Museum, specimens from Falls Church, Va. (A. N. Caudell) and Thompsons Mills, Ga. (H. A. Allard) appear to belong to this race.

The subspecies *tinnulus* represents one extreme in the evolution of the *fasciatus* (De Geer) group with *socius* Scudder as the other extreme. The race *abortivus* Caudell from the northern prairie regions seems to be an offshoot in another direction toward *N. griseus*. After studying the races *tinnulus*, *fasciatus* and *socius* in Iowa and North Carolina, both in the field and the laboratory, the writer has formed a different conception of them than that of geographical races based on the relative length of the ovipositor and hind femur. It is true that *socius* in the southern states where it is the commonest race has a relatively short ovipositor but in northern grass marshes there exists a form which is similar to *socius* in habits and in appearance, with the exception of the ovipositor length. The woodland specimens from Mt. Pleasant, Iowa which I am referring to *tinnulus* also have longer ovipositors than the southern specimens but they agree in other characters and in habits. On the other hand, I have recently found in restricted environment near Raleigh, crickets which have as long ovipositors as *fasciatus* in the north and which have other morphological characters and song habits agreeing with that race. The problem is complicated by the fact that the above crickets which appear to be *fasciatus* have a very restricted habitat while in the north, it is the most widely distributed race. In North Carolina, *socius* is widely distributed and tolerates a rather wide range of environmental conditions while the cricket in the north that resembles it has a restricted environmental range.

If we are to recognize any subspecies of *fasciatus* we have at present two choices for the basis of separation. The first is the single female character of relative ovipositor length which offers no more clear cut line of demarkation than any of the characters in the second choice and leaves in both groups physiologically distinct races. The second choice is a combination of characters including the shape of the male tegmen and the relative proportions of some of its areas, the number of teeth in the stridulatory vein, slight differences in the tip of the ovipositor, and some differences in coloration applicable to

both sexes. These differences are correlated with physiological differences recognizable in song habits, seasonal history and in the choice of environment. The above characters are not a direct result of environmental influence for all races have been bred from the nymph in the laboratory under identical conditions and all remain true to type both in structural characters and song. Also in certain border line areas two races may be found intermingled but apparently not intergrading. There appears to be inherent differences between the races which cause them to choose different environments.

My studies have led me to place greater confidence in the second basis of separation as outlined above and to consider the subspecies of *fasciatus* as ecological races rather than geographical. This conception greatly extends the recognized range of *socius*. It is admitted that the characters described below will not suffice to place many specimens from a miscellaneous collection into one of the three subspecies. But neither can this be done on the relative length of the ovipositor. The advantage of the geographical conception of the subspecies is that they can be classified by the locality labels. If locality labels also bore ecological data, they would help in the same way with my classification. Thus it is apparent that certain song and habitat differences noted by Allard (3) in Mass. are those of the races *fasciatus* and *socius*.

I believe that the three subspecies are physiologically distinct and that any individual belongs to one of the three, but that morphologically they have not diverged far enough to make exact classification possible. For this reason I see no reason why any of these crickets should not be referred to merely as *Nemobius fasciatus* in any general discussion where fine distinctions are not involved.

The following outline of racial characters will aid in determination of the subspecies. With a series of specimens taken from a single type of habitat the average condition found will probably indicate the race.

Male right tegmen: Spaces mentioned are shown in Fig. 2, A. Space a, length of stridulatory vein between the crest of the vein which it joins at the inner margin and the perpendicular branch near the middle. Space b, from the above mentioned branch to the outer margin of the dorsal

field. Space c, from the stridulatory vein to tip. Measurements of the extremes in millimeters.

No. of Specimens	Locality	space a	space b	space c	a minus b (algebraic)
<i>Tinnulus.</i>					
8	Raleigh, N. C.	1.3 to 1.5	1.1 to 1.3	3.4 to 3.9	.1 to .3
5	Mt. Pleasant, Iowa	1.3 to 1.5	1.2 to 1.4	3.6 to 4.2	0 to .3
7	Reidsville, N. C. ...	1.2 to 1.4	1.2 to 1.3	3.5 to 4.	0 to .1
<i>Fasciatus.</i>					
8	Iowa, (mostly from Ames)	1.1 to 1.2	1.0 to 1.3	3.4 to 4.2	-.1 to .2
12	Raleigh, N. C.	1.3 to 1.4	1.3 to 1.5	3.8 to 4.4	-.2 to 0
3	Burnsville, N. C. ...	1.0 to 1.3	1.1 to 1.2	3. to 3.5	-.1 to .1
<i>Socius.</i>					
20	Raleigh, N. C. ....	.7 to 1.0	.9 to 1.3	2.8 to 4.2	-.4 to -.1
8	Ames, Iowa. ....	.7 to 1.0	1.0 to 1.3	3. to 3.8	-.3 to -.1
4	Geneva, N. Y. ....	.8 to .9	1.1 to 1.2	3.3 to 4.	-.4 to -.2
5	Chadbourne, N. C.	.8 to 1.0	1.1 to 1.3	3.4 to 3.8	-.4 to -.2
6	Phelps Lake, N. C.	.8 to .9	1.0 to 1.2	3.2 to 3.8	-.4 to -.2
5	Fort Collins, Colo..	.8 to .9	1.2	3.3 to 3.5	-.4 to -.3
7	Albuquerque, N.M.	.9 to 1.1	1.2 to 1.4	3.4 to 4.2	-.4 to -.2

The male tegmina in *tinnulus* are generally large compared to the size of the body although only wingless forms have been found. In *socius* the tegmina are relatively smaller except in the macropterous forms which are sometimes found. In the former race, the tegmina are broader in comparison to the length and the tips are more broadly rounded. The tegmina of *fasciatus* are intermediate in all respects. Winged forms of the last race also occur.

The number of teeth in the stridulatory file varies considerably between the three races. Unfortunately, this cannot be determined without removing one of the tegmina and mounting it on a slide for examination under high magnification. There seems to be some variation within each race, correlated with size of tegmen, but a very small *tinnulus* has more teeth in the file than a very large *socius*. Counts made of various specimens are as follows:

Tinnulus—Raleigh, N. C., 228, 239; Sparta, N. C. (smallest, exposed portion 3.4 mm.) 187; Mt. Pleasant, Iowa, 208.

Fasciatus—Ames, Iowa, 185, 197; Grandfather Mtn., N. C. (small, 4.6 mm.), 184; Raleigh, N. C. (largest, 6 mm.), 192, 194.

Socius—Raleigh, N. C., 105, 129, 145, (smallest) 115; (largest) 140; Ames, Iowa, 113, 117, 126; Geneva, N. Y., 127, 139.

Typical examples of the male claspers of *tinnulus* and *socius* are shown in Fig. 1. The greatest difference is in the ventral lobe which is acutely pointed in the former and rounded in the latter. In *fasciatus* an intermediate condition is found. There is some variation in all three races so that the character is of no greater diagnostic value than the others mentioned.

The table below gives the measurements of the ovipositor (dorsal edge to expanded basal portion), hind femur, and the individual difference of the first minus the second, expressed as minus quantity when the femur is longer than the ovipositor.

No. of Specimens	Locality	Ovipositor	Femur	Ovipositor minus Femur (algebraic)
<i>Tinnulus.</i>				
10	Raleigh, N. C.	6.2 to 7.8	6.2 to 7.6	-.6 to .6
6	Reidsville, N. C.	7.0 to 7.8	6.8 to 7.8	-.2 to .7
4	Sparta, N. C.	6.4 to 8.1	5.4 to 6.8	.9 to 1.7
3	Mt. Pleasant, Iowa	7.6 to 8.8	7.3 to 7.7	0 to 1.3
<i>Fasciatus.</i>				
18	Ames, Iowa	6.2 to 8.2	6.4 to 7.6	-.6 to 1.4
8	Mt. Pleasant, Iowa	7.0 to 9.0	6.6 to 8.2	0 to .8
6	Pointe au Baril, Ont	8.0 to 9.1	6.5 to 7.0	1.0 to 2.5
7	Burnsville, N. C.	6.2 to 7.2	5.7 to 6.6	.2 to .8
26	Raleigh, N. C.	7.8 to 9.4	7.2 to 8.8	0 to 1.0
<i>Socius.</i>				
29	Ames, Iowa	6.4 to 8.6	6.1 to 7.8	-.2 to 1.0
12	Sparta, N. C.	5.8 to 7.8	6.2 to 7.4	-.4 to .7
21	Raleigh, N. C.	5.2 to 7.4	5.8 to 7.6	-.7 to 0

The above figures show that there is no correlation between relative length of ovipositor and hind femur, and the races as here defined. Considered geographically, there is some correlation but there is so much variation in one locality that the extremes greatly overlap. Thus by lumping all specimens from Raleigh, N. C. and all from Iowa we would get a range of -.7 to 1.0 for Raleigh and -.6 to 1.4 for Iowa.

In the shape of the tip of the ovipositor there is a slight difference between the races, typical examples of which are shown in Fig. 2. In *tinnulus* and *fasciatus* there is a slight curve to the dorsal outline of the toothed portion, intensified by the fact that there is a considerable increase in the size of the teeth toward the tip. There are usually 8 or 9 teeth visible in profile in *tinnulus*, 9 or 10 in *fasciatus* and 11 to 13

in *socius*. In the last the toothed portion is straight and none of the teeth are very large. These characters are often destroyed by the use of the ovipositor. In many specimens all of the teeth have been worn completely away.

The coloration of all three races varies so much that little dependence can be placed on it as a character. On the average *tinnulus* is more tawny. The head is pale or dark reddish brown but in either case the dark markings, if present at all, are inconspicuous. The face below the median ocellus is only slightly darker than above, if at all. The dorsum of the pronotum is more uniform in color and usually pale, but if dark, the lateral portions are only slightly paler and not conspicuous stripes. In *fasciatus* the usual color is dull brown to nearly black with head markings and lateral stripe on dorsum of pronotum more distinct. The face below the median ocellus is usually considerably darker than the ground color above. In *socius* the color is often almost entirely black but if paler, the markings are quite contrasted. The head stripes may be reduced but usually they are black and the face below the ocellus is often black. The dorsum of the pronotum is generally dark or black with distinct buffy lateral stripes. The dorsum of the exposed abdominal segments in pale specimens has a continuous pale median line bounded by black lines while light specimens of the other two races have the median line black with at most a pale median dot at the caudal border of each segment. This difference applies to the whole abdomen in nymphs.

SEASONAL HISTORY.

The seasonal history of *socius* at least in the Piedmont and Coastal Plain of North Carolina differs from that of *tinnulus*. The former begins to mature before the middle of June, and small nymphs of a second generation appear in the latter half of July. In the laboratory nymphs hatched out within two weeks after adults had been placed in a cage. Nymphs may be found until late fall and it is entirely possible that there may be a partial third generation. No adults have been found of *tinnulus* until after the first of August in the past two years. There is no evidence of more than one generation. No observations have been made on the seasonal history of *fasciatus* in this region for it was not discovered here until the

middle of October, 1930. In Iowa the earliest record I have for adults of *socius* is July 5, 1926 and for *fasciatus* August 3 of the same year but no effort was made to determine the earliest appearances. On August 1, 1929 near Pomeroy, Ohio an effort was made to find all three races but *socius* was the only one that could be heard singing.

After *socius* the earliest species to mature in N. C. are *carolinus*, *cubensis*, and *funeralis*. Adults of all three may be found at Raleigh about the first of July. In the southeastern part of North Carolina adults of *carolinus* and *cubensis* were found on June 22. All three species probably have more than one generation during the summer. Near Raleigh adults of *confusus* have been taken as early as July 29 but none of *palustris* earlier than August 12 at which time there were many still immature. The earliest catch of *bruneri* is September 10 but at that time only a few nymphs were present.

CROSSING EXPERIMENTS.

At the borders of woods, *tinnulus* and *socius* are sometimes found intermingled over very limited areas. Some experiments were performed to see whether they might mate with each other. Female nymphs of both kinds were collected and kept in cages until maturity. Then they were caged with males as outlined in the table below. After a number of days the females were killed and the seminal receptacles dissected out. When filled with sperms the receptacle is distended and glistening white, otherwise it is collapsed and translucent. All unfilled ones were examined under high magnification to see if any sperms were present.

In the five experiments where the crickets were caged with their own kind seminal receptacles were completely filled. Of the seven experiments where they were caged with another race only, two showed no traces of sperms in the receptacle. In three of the four experiments where the male was caged with females of both kinds, the receptacle of the female of different race showed no trace of sperms and in the fourth, only a few, as if from one mating.

In two larger cages several females of each race were placed with males of the other race. The cages were kept in a screened insectary over winter and the soil watered occasionally. No

offspring were obtained the following summer. No check was run with crickets mated with their own race so the results are entirely negative.

Females	Males	Number of Days Together	Condition of Seminal Receptacle
Tinnulus	Tinnulus ..	13	Filled.
Tinnulus	Tinnulus ..	8	Filled.
Tinnulus	Tinnulus ..	14	Filled.
Tinnulus	Tinnulus ..	14	Filled.
Socius	Socius ..	24	Filled.
Tinnulus ..	Socius ..	8	Filled.
Tinnulus ..	Socius ..	18	Empty.
Tinnulus	Socius ..	18	Filled.
Tinnulus	Socius ..	18	Filled.
Tinnulus	Socius ..	14	Empty.
Socius ..	Tinnulus ..	37	Filled.
Socius ..	Tinnulus ..	37	Filled.
Socius and Tinnulus	Socius ..	6	Socius filled; Tinnulus empty.
Socius and Tinnulus	Socius ..	24	Socius filled; Tinnulus empty.
Socius and Tinnulus	Tinnulus ..	6	Socius empty; Tinnulus filled.
Socius and Tinnulus	Tinnulus ..	24	Socius with few sperms; Tinnulus filled.

During the summer of 1930 similar experiments were run with the addition of *fasciatus* from the mountains. All three races have been caged with their own kind and the two other races. They have been kept in large glass jars with previously heated sand and soil in the bottoms. No offspring appeared during the fall so the jars will be kept at outdoor temperatures until spring.

MACROPTEROUS FORMS.

Individuals with long hind wings greatly exceeding the tegmina have been found in the following species: *fasciatus fasciatus*, *fasciatus socius*, *griseus griseus*, *griseus funeralis*, *cubensis*, *carolinus* and *mormonius*. Blatchley's (4) record of a macropterous specimen of the last species from Yuma, California is probably correct but the Texas macropterous specimens mentioned by Hebard (1) may prove to be *bruneri* if the

male genitalia are examined. The macropterous individuals are often attracted to lights at night in large numbers. They probably serve to disseminate the species.

In looking through collections, it was noticed that there are some individuals both male and female, with longer tegmina but without wings. An examination of some of these specimens showed that they do not have the usual vestigial wings but that the wings have been broken off at the base. They have a peculiar development of the metanotum and first abdominal tergite which is found only in macropterous forms. (Fig. 3.)



FIG. 3 Metanotum and first abdominal tergite of (A) micropterous form and (B) macropterous form with wings broken off.

This summer I had placed a macropterous *fasciatus* male with a female in a cage. A few days later the male had no wings and there was no trace of them in the cage. I thought that the female had probably chewed them off. The next macropterous individual that I found, which happened to be a male *funeralis*, I placed by itself in a cage. The next day it had no trace of wings and they could not be found in the cage. It must have broken them off in some way and devoured them. It seems reasonable to conclude from these observations that the wings of macropterous forms are not kept throughout their life and that such individuals settle down to an earthly existence, possibly after having migrated to new territory.

SONG HABITS

The males of the genus *Nemobius* are persistent singers both by day and night. Their songs are neither very loud nor of very musical quality. With the exception of two species which sing alike all have characteristic types of song which can be recognized in the field by anyone who has learned their peculiarities. The best way to study the song habits is to

cage a few pairs where they will be away from the confusion of other insect sounds. In this way I have learned the songs of all the eastern species with the exception of *N. griseus griseus* E. M. Walker.

In recording the peculiarities of an insect song for the purpose of identifying it later in the field, the most important feature is the time element, which can be measured with greater accuracy than pitch, tone quality or loudness. The songs of various species of insects present so much diversity in length and frequency of notes, meter and rhythm that only modifications caused by extremes in temperature are apt to confuse them.

The question may arise as to why anyone should want to recognize the song of a *Nemobius* or any other insect. It may be for the same reason that many people learn the songs of birds, simply for the pleasure of knowing what causes the sounds. Another reason is that this knowledge facilitates the study of interesting problems in ecological distribution, by enabling the investigator to know where the various species live without the difficult task of finding them. From the collector's standpoint there is the added value that rare species may be located by tracking down the unusual song.

When singing the male *Nemobius* raises the tegmina to about a forty-five degree angle with the body and spreads them apart a little. They are then vibrated in a transverse direction. As with most crickets the right tegmen in *Nemobius* is always uppermost. The two tegmina are not identical. The right is slightly more infuscated and has a rougher surface. The left only has a narrow bead or raised edge on the inner margin where it comes in contact with the stridulatory vein of the right. Both have a well developed file or series of minute transverse ridges on the under surface of the stridulatory vein.

Several species of *Nemobius* produce more than one type of notes. One type which may be termed the calling song is produced when the male is alone or not sexually excited and is the one most frequently heard. The other which I have termed the mating song is used when the male is actively courting the female. During this song he is generally facing the female and puts on something akin to a dance by jerking the body backward and forward in time with the sounding of the notes. If the female departs during this performance he will

again resume the calling song. Old males often have a weak song as if the file had become worn with use.

The following key applies to the calling songs at temperatures of 70° F. or higher:

- I. Made up of repeated short notes never much over a second in length and never so rapid but that the individual notes can be plainly heard.
 1. Sharp metallic chirps, with constant rhythm, 6 to 9 per second.
N. fasciatus tinnulus n. subspecies.
 2. Notes of rougher quality, observable variations in rhythm, 3 to 7 per second.
N. fasciatus socius Scudder.
 3. Longer notes, one-half to one second in length.
 - a. Non-rhythmical, occasional notes 2 to 3 seconds long.
N. sparsalsus Fulton.
 - b. Rhythmical but not very constant, notes of more uniform length.
N. ambitiosus Scudder.
 - c. Each note begins as a low buzz with two undulations, audible only a few feet away, then increases in volume to the end, intervals between notes very brief; rhythmical, but not constant.
N. confusus Blatchley.
- II. Sound continuous for several seconds at a time.
 1. Notes and rests of about equal duration, usually 5 to 15 seconds.
N. cubensis Saussure.
N. palustris Blatchley.
N. palustris aurantius R. and H.
 2. Song interrupted at irregular intervals, usually 5 to 10 seconds, by breaks of less than a second duration.
N. griseus funeralis Hart.
- III. Song usually continued for indefinite period.
 1. Of shrill tinkling quality without modulations.
 - a. With evident tremolo; at lower temperature song becomes a rapid series of sharp chirps, but at summer temperatures these are at a rate estimated at 12 to 15 per second.
N. fasciatus fasciatus (De Geer).
 - b. A thin high pitched sound with a tremolo so rapid that it can scarcely be detected at summer temperature.
N. bruneri Hebard.
 2. With modulations.
 - a. A weak tinkling sound with regular rhythmical undulations 5 to 7 per second.
N. maculatus Blatchley.
 - b. With a droning quality, variable in volume, part of the time louder and with rapid undulations, at other times weaker, lower pitched, without undulations.
N. carolinus Scudder.

The song of *N. fasciatus fasciatus* is one of the loudest in the genus. The calling song is a continuous high pitched tinkling metallic sound. One can imagine that it might be produced by a small bell attached to the end of a length of spring steel that vibrates with about 10 to 15 swings per second. The sound is actually a series of short distinct chirps but at 80° F. or above this quality can scarcely be recognized. On cool days the chirps are plainly apparent and can be estimated

by tapping a paper with a pencil point at as near the same rate as possible for a period of a few seconds moving the pencil along so that the dots can be counted and the number per second computed. Estimates were thus made of Iowa specimens at 50° F., between 5 and 6 chirps per second, at 61° F., about 8 or 9. Specimens from North Carolina mountains chirped close to 7 times per second at 60° F., at least 8 per second at 66° F. and over 9 per second at 68° F. Specimens from Raleigh, N. C. appear to have a slightly higher rate than the mountain specimens.

In watching a male singing it appears as if each chirp were produced by a single movement of the tegmina. The movement is too rapid to be visible. The tegmina seem to be held motionless at the outer limit of the swing indicating that they must be held stationary in this position for a brief period between each stroke.

There are two variations of the mating song. When a male is facing a female it sometimes sings as described above in short phrases about one and one-half to three seconds duration, with rests of about half a second. At other times the male chirps louder and at much slower rate, about 5 to 6 per second, without regular rhythm and accompanies some of the notes by jerks of the body backward and forward.

The song of *N. fasciatus* could be confused only with *N. bruneri* and *Anaxipha exigua*. The former is generally weaker and with a much more rapid tremolo, which is clearly evident only at rather low temperatures. The latter is similar in movement but much more musical and bell-like in quality than any *Nemobius*.

The song of *N. fasciatus tinullus* differs from typical *fasciatus* only in the frequency of chirps. Instead of appearing like a continuous sound the separate chirps are evident at all temperatures. By estimating the rate as previously described, when too fast to count, specimens at Mt. Pleasant, Iowa were found to chirp at the following rates per second: 7 and 8 at 80° F., 5 and 5.7 at 66°, 4.4 at 65°, 4.3 and 5 at 61°, and 3.8 at 59°. Specimens from Raleigh, North Carolina gave the following rates: 7 at 82° F., 8 at 79°, 7 at 75°, 6 at 69°, 5.5 at 67°, 5 at 66°, 4 at 60°; from N. C. mountains: 7 to 8 at 80°, 5 at 66°. In the mating song the notes sounded at about half the above rate, less rhythmically but sharper and more emphatically.

The song of *N. fasciatus socius* differs from the other two races in tone quality and in the method of production. In place of brief sharp chirps, the notes are longer and appear to be a combination of a low buzzing sound and a weak shrill sound. When the movement of the tegmina is observed at ordinary summer temperatures it appears to be a single slow inward movement for each note. When observed at lower temperatures it becomes apparent that each movement is accompanied by a rapid vibration of the tegmina, with a short amplitude. With the temperature near 60° F., there is a perceptible quaver in the notes, which are longer and slower than at higher temperatures. In cool weather the notes seem to be clearer and the shrill quality is more evident. It seems probable that vibrations caused by the teeth in the file produce the shrill element in the sound and that at high temperatures this passes beyond the range of human hearing leaving the buzzing sound caused by the tegminal vibrations as the most audible element of the sound.

Males of *socius* show considerable variation as to the frequency of notes and the same individual may vary the rate from time to time. Rates per second observed at different localities are as follows: Ames, Iowa, 2.5 to 3 at 77° F., 4 at 80°; Raleigh, N. C., 3 to 5 at 86°, 4 to 6 at 88°, Ripley, W. Va., 3 at temperature probably over 90°; Geneva, N. Y., 3 to 5, crickets in the sunlight and temperature well above 80° in the shade. At 66° a Raleigh male sang only 7 notes in 5 seconds.

The presence of a female influences the rate of notes even when the male is not singing his characteristic mating song. Three Raleigh males caged alone had somewhat different usual rates. At 86° F. they ran about 3, 4 and 5 notes per second respectively. When females were placed in the cages it was noticeable that after a few minutes all three were singing faster. The third increased to about 7 per second, the second to nearly 8 and the first only to 4 or 5. The mating song is similar to the above except that there is a brief pause after a series of 5 to 9 notes and the last note of each series is slightly prolonged with a decrescendo movement. This note is accompanied by a backward jerk of the body.

In a cage containing a large number of *N. socius* a slightly different note is frequently heard, especially among new arrivals from the field. As they meet when crawling about the cage

they will stop and sound one or two loud notes of about a second duration. It seems to result more often from the meeting of two males.

The song of *N. sparsalsus* has almost no rhythm. Notes of a half to one second duration may be repeated for a time with some regularity at a rate of about 3 in 5 seconds but, at intervals, longer and louder notes of 2 or 3 seconds duration are thrown in. The song is not loud considering the size of the cricket and the quality is like a shrill sound and buzz combined. Individual notes, especially the longer ones, remind one of *N. cubensis* in that they increase in volume and pitch. The mating song is brief chirps at the rate of 3 or 4 per second. These generally come in series of 2, 3, or 4 with slightly longer pauses between. Longer notes are frequently mixed in with the short chirps.

The song of *N. maculatus* is comparatively weak. It is a continuous buzzing trill with a constant rhythmical undulation in volume having a frequency about equal to the chirping rate of *tinnulus*. On cool days a very rapid tremolo is apparently corresponding in time to the strokes of the tegmina. The undulations or beats each cover a number of strokes. An Iowa specimen at 61° F. had thirty-six beats in ten seconds; at 70° about six per second. No distinct mating song has been observed.

The song of *N. griseus funeralis* is the most monotonous of any of the genus. It is a low weak buzz with a faint shrill overtone. It can be identified by the frequent breaks or pauses of a small fraction of a second that come at intervals of 5 to 10 seconds with little regularity. At times it may continue for 15 to 30 seconds without a break. As the sound is resumed after each break it starts with reduced volume and pitch in a crescendo movement covering a third to half a second after which a uniform tone is maintained. The mating song is very brief sharp chirps of possibly a fifth of second duration, produced without regular rhythm at an average rate of 14 in 10 seconds at 78° F. During this song the male jerks its body forward and backward.

The song of *N. bruneri* somewhat resembles that of *N. maculatus* in its extremely rapid tremolo but lacks the beats. It is as if the song of typical *fasciatus* were speeded up to such a high frequency that the tegminal strokes are barely perceptible.

It is a continuous trill like that of *Oecanthus nigricornis* but weaker and higher pitched. The pitch must be close to the upper limit audible to the human ear. Only one type of song is produced.

The writer heard *N. mormonius* singing along the edge of a small stream on the Bright Angel trail in the Grand Canyon, and described it in his notes as a continuous trill resembling the song of *Oecanthus nigricornis*. At that time he did not know the songs of the other species and could not make critical comparisons.

The songs of *N. cubensis* and *N. palustris* are very much alike. Both have notes of several seconds duration with approximately equal intervals of rest. The pitch is very high and the quality may be described as a thin whistle, meaning that the sound is not a pure musical tone. The song of *palustris* seems to be a little clearer than that of *cubensis*. Each note very gradually increases in volume until it ends abruptly. At Geneva, N. Y. on a hot day the notes of *palustris* were observed to be 5 to 10 seconds in length and the rests 5 to 10 seconds. At Raleigh, N. C. no difference in the song could be noticed. The species here has paler colored legs, head, and pronotum and is close to if not identical with *N. palustris aurantius* Rehn and Hebard.

The song of *N. cubensis* observed at Raleigh, N. C. had notes and rests usually from 8 to 15 seconds in length but some notes were as short as 2 seconds and others as long as 30 seconds. As a rule each male, when singing regularly has a fairly constant length of note. One at Carolina Beach had notes regularly 10 seconds long. No special mating song has been observed for either of the above species.

The song of *N. ambitosus* was determined from living specimens collected in Dixie Co. and Alachua Co., Florida, by T. H. Hubbel. It has a rather low pitched song compared to some of the other species and the quality is rather musical and pleasant. When the crickets arrived, April 2, it is probable that none had been in the adult stage very long judging by the fact that many were still nymphs. For a while they all sang at a rather slow rate of about 6 notes per 10 seconds. Each note has a slight crescendo movement and ends abruptly. There is also a noticeable tremolo effect. A week after they arrived one was observed to have speeded up the song and was found to be

singing to a female. The rate was very changeable from 10 to 20 notes per 10 seconds at a temperature of 77° F. Sometimes the notes were very brief and weak, about one per second, at other times they were drawn out to nearly two seconds each with very brief pauses between so that the song was almost continuous. On another day, at 77° F., one was singing 15 to 16 notes in 10 seconds and another 9 to 12. At 61° F. one sang 5 notes in 10 seconds and another at 58° 6 notes in 10 seconds. At these temperatures the notes were very weak and distinctly tremolo. Only one male from Dixie Co. lived and it never sang at as fast a rate as the others. At 87° it had 8 notes per 10 seconds and at 80° only 7 notes.

The song of *N. carolinus* reminds one of the distant droning of some species of cicadas. The tone quality is like that of *N. griseus funeralis* and *N. confusus*, a low buzz with a thin shrill overtone. At times it has a rhythmical beat like the song of *maculatus* but a little more rapid. It sounds as if the singer were quivering with nervous energy. If one listens to a single song closely, the beat will be found to die out and the song will run along at reduced volume, sometimes seeming about to die out. Then it will gain in force again and tremble as before. Rarely males will be heard that seldom sing without beats but usually there is a regular repetition of the two phases of the song, sometimes one second for each period and sometimes longer. Sometimes when starting to sing this species will sound a few notes which increase in volume and then die out. No special mating song has been observed, although the song as described above has been heard many times both in Iowa and North Carolina and the two sexes have been caged together.

The most unique song in the genus is that of *N. confusus*. It has a constant meter of two brief weak notes and a longer louder one. Some individuals have been heard with three of the weak notes. The weak notes can be heard only a few feet away so that at a little distance the song seems to be a repetition of a single note, the loud one. The three notes are really not distinct but are a single note with two short rises in volume and then a greater increase till the end of the note after which there is a brief pause before the next is started. It is a droning buzzing trill like the song of *carolinus*. The rate of song varies somewhat. One in Iowa, at 70° F., was observed to

start at a rate of one complete note per second and at times increased to two per second. At Raleigh, N. C. one sang with 9 to 10 notes in 10 seconds at 75° and 10 to 12 notes at 80° . No special mating song has been observed, although males have been caged with females.

MATING HABITS.

Preliminary to mating the male faces the female and sings. In many species it has a special mating song for such occasions. At the same time it performs something like a dance by jerking

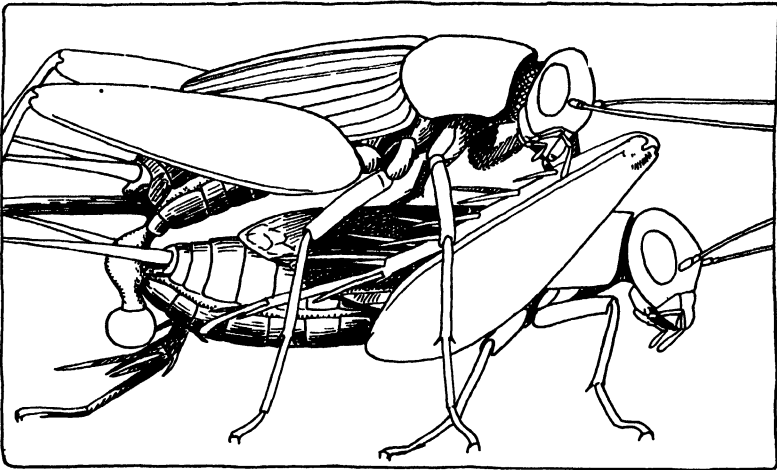


FIG. 4. Female (upper) feeding on secretion of specialized spine on male hind tibia during mating.

the body backward and forward without changing the position of the feet. The genitalia are protruded as shown in Fig. 5, D, but the spermatophore is not formed until a short time before mating takes place. It appears in a partially formed condition as a slightly elongated drop of milky white viscous liquid which is pushed out of the genital opening. It soon becomes spherical and remains suspended from the concavity formed by the extremity of the fleshy ventral portion of the genitalia.

Shortly after this the male turns around, drops the tegmina and backs toward the female. At the same time it raises one hind femur with the tibia closed upon it and brings it forward so far that it is inverted. The female crawls over the male

and begins to bite at the specialized proximal internal spine on the hind tibia. This brings the female far enough forward that the male can push the claspers into the opening between the ovipositor and subgenital plate (Fig. 4). They remain in this position usually from 15 to 25 minutes, the female all the time biting at the spine, sometimes running the mouth along the tibia but always coming back to the proximal internal spine. When she leaves the male, the spermatophore remains attached to her and later she removes it and eats it.

The specialized structure of the proximal internal spine of the male hind tibia, has been published on by Pantel (5) but he did not know its function. It stands perpendicular to the tibia and is much thicker and shorter than the same spine in the female. The base is dark while the apical portion is white and thin walled. In some specimens it has a dark slightly hooked tip, but in the majority, the apical portion has been removed probably by a female cricket (Fig. 5, A, B). Parts of some of the neighboring spines are sometimes missing also. Speaking of the internal structure of the modified spine Pantel says that the "hypoderm forms a massive tissue, a sort of muff of thick wall with cavity very much reduced." The constitution of the contents of the cavity he says is "undecipherable in my preparation." What he found in the cavity was probably a viscous secretion. If a male cricket is etherized and one of the mutilated modified spines is touched with the point of a pin, a viscous liquid usually adheres to the point and will pull out into a thin thread. After repeating this a few times, the supply seems to become exhausted.

There can be little doubt but that the function of the modified spine is that of an alluring gland similar to the metanotal gland in *Oecanthus*. Females have sometimes been observed to bite at the spine when no mating is taking place, but the male does not permit the female to continue this unless a spermatophore is being formed.

The fully formed spermatophore (Fig. 5, G) has a spherical body about one and a third millimeters in diameter and with a flattened, curved tube about two and a half millimeters long. Near the tip there is an expanded portion, molded in the groove between the claspers. The extreme tip curves slightly in the opposite direction. The walls and tube are composed of a clear hard substance. A capillary opening extends through the tube to the tip.

The formation of the spermatophore is a complicated process which is difficult to understand. When it first appears on the male it is sometimes possible to etherize the cricket without dislodging the spermatophore. If it is examined in place, we find the forming tube as a narrow ribbon of viscous liquid extending along the groove between the inflated lips on

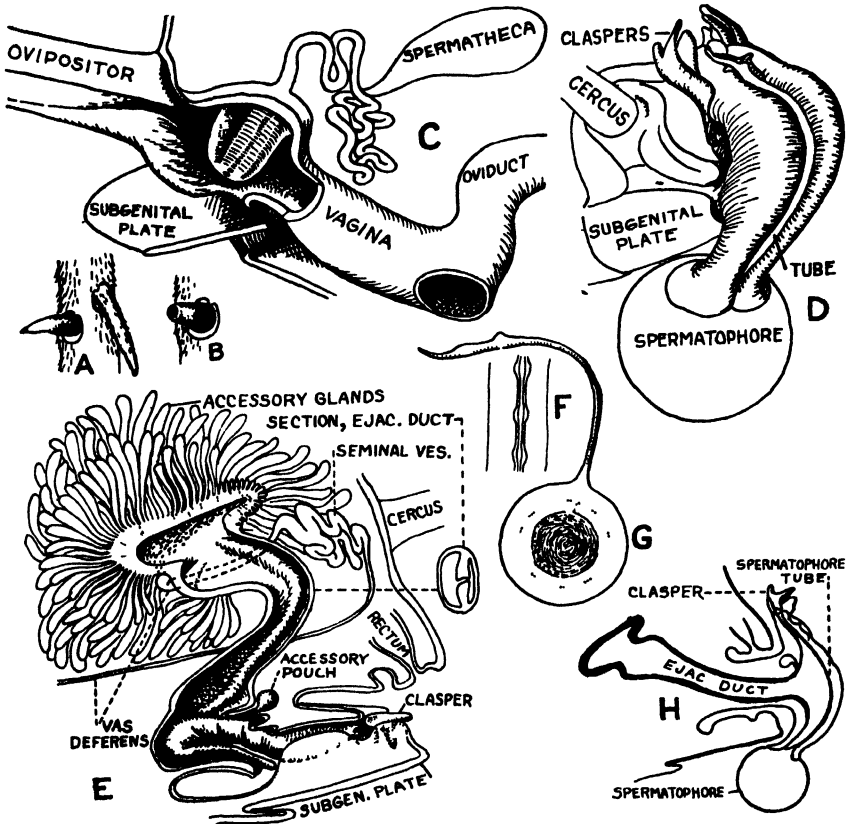


FIG. 5. A, Specialized spine of male hind tibia (left) and unspecialized spine (right). B, Specialized spine as usually found with tip removed. C, Female genital organs, showing knob-like invagination of dorsal wall of vagina. D, Male external genitalia during formation of spermatophore, caudo-lateral view. E, Male genital organs in resting position, as if cut through the median line. F, Portion of spermatophore tube in semi-liquid condition showing included capillary tube of different substance. G, Spermatophore, showing central sperm mass (shaded), surrounding liquid and hardened outer wall. H, Diagram of approximate position of male organs during spermatophore formation.

the caudal aspect of the genitalia, from the body of the spermatophore to the distal end of the rigid groove between the claspers (Fig. 5, D, H). If this strip is examined under a microscope while still in a semiliquid condition there appears to be within it a thin walled capillary tube of different substance, which is easily broken by handling as if it were also in a semiliquid condition (Fig. 5, F). This tube extends into the body of the spermatophore.

If the body of the spermatophore is compressed under a cover glass while still a milky liquid, the sperm mass is found to be already present. The surrounding substance becomes clear in a few minutes and under the microscope becomes granular in appearance. Thin streams of liquid carrying granules are seen moving away from the edge. The substance appears to be a colloidal solution in which a clotting action is taking place, with a squeezing out of a liquid phase toward the center.

The normal development of the spermatophore can be followed best by suspending it under a cover glass without crushing it. As soon as it clears the sperm mass can be seen surrounded by a thin membrane. For several minutes the sperms can be seen swimming around in the mass all going in the same direction. The outer surface of the spermatophore, which is like a thin membrane at first gradually becomes thicker and harder. The sperm mass is surrounded by a layer of liquid. By contraction of the outer wall a pressure is developed which breaks the thin side where it is flattened by the cover glass and the sperms pour out. The thin membrane surrounding them collapses and empties. The central cavity is then filled with a liquid in which some further clotting takes place, forming suspended particles and fern-shaped concretions.

When the spermatophore has been allowed to harden normally on the male the pressure developed by hardening and drying will force the sperms through the capillary tube. If this inner tube becomes dislocated, as usually happens when the spermatophore is removed before completely formed, the contraction of the outer wall results in a gaping split, releasing the contents. If immersed in water, the outer wall takes up water, expands, and the split closes again.

While the spermatophore remains attached to the female, the sperms pass into the seminal receptacle or spermatheca. The tip of the spermatophore tube must enter a small hole in a

knob-like invagination of the dorsal wall of the vagina, situated above the base of the subgenital plate between a pair of fleshy pads attached to the ventral rods of the ovipositor (Fig. 5, C). This knob has a thin but somewhat rigid wall and is about the right size to be grasped by the male claspers, which would bring the tip of the spermatophore tube close to the hole in the apex of the knob. A tube passes through the knob, and with many convolutions leads to the spermatheca.

The complicated male organs are shown as if cut directly through the median line in Fig. 5, E. There are a large number of accessory glands which undoubtedly secrete the substance of the spermatophore wall. A dorsal group of these are very small, short tubes. The large common duct has lateral invaginations which meet and divide the space into two passage ways. Near the base of the claspers there is a pair of thin walled pouches of unknown function. The ventral thin walled portion of the external genitalia is much inflated in use and is folded up when withdrawn into the body.

ECOLOGY.

As previously pointed out the recognition of the characteristic type of song for each species of *Nemobius* has greatly simplified the study of their distribution. I would frequently check up on my memory by capturing a specimen if there was any doubt about the identity of the song. Once the songs have been thoroughly learned, it is only necessary to listen carefully to determine what species are present and their approximate abundance in any locality.

There is a surprising exactness about their distribution. Once the rules have been learned one can look at a varied landscape and enumerate what species of *Nemobius* will be found in the various parts of it. Some species range widely and others are narrowly restricted in their environment. Unlike many insects these crickets are not bound by specific plant food relations, but their occurrence is rather closely related to the plant community. Without experimental verification the following factors seem to influence the choice of habitat: moisture, ground cover, food supply near the ground level, temperature or sunlight and shade relations. If a combination of factors favorable to any one species is generally found in a plant community, the local distribution of the cricket will follow that community.

The species which are commonly associated with certain plant communities in North Carolina are given below, taking up first the successional stages originating from an abandoned field, as outlined by Wells (6).

1. Crab grass (*Syntherisma sanguinale*) *Nemobius fasciatus socius*. This passes into an association of tall weeds with consequent elimination of grass, becoming an unfavorable habitat for *socius* when complete.

2. Broom-sedge (*Andropogon virginicus*) *Nemobius griseus funeralis*. This stage follows the tall weeds. Some *socius* may be found in it, but *funeralis* is often the only species especially on sterile soils where the clumps of *Andropogon* are well separated.

3. Pine woodland, (*Pinus taeda*, *P. echinata*) *Nemobius fasciatus tinnulus*. In the intermediate stage, before the pines have crowded out the *Andropogon*, *N. funeralis* may still be found between the pines. As soon as the pines attain size enough to cast considerable shade, *tinnulus* comes in.

4. Oak woodland (*Quercus marylandica*, *Q. stellata*) *Nemobius fasciatus tinnulus* and *N. confusus*. The latter, which is never abundant, can tolerate deeper shade than the former.

5. Mesic forest (*Quercus*, *Carya*, *Acer*, *Fagus*) *Nemobius maculatus*, *N. confusus*, *N. Carolinus*. The last may be found in locally moist places in any of the successional stages leading up to the climax, but becomes more numerous and widely distributed in the climax forest.

6. Salt marsh (*Juncus roemerianus*, *Spartina stricta*) *Nemobius sparsalsus* and *N. cubensis*.

7. Fresh water marsh (*Typha latifolia*, *Scirpus* spp.) *Nemobius cubensis*, *N. carolinus*, *N. fasciatus socius*. The last is not found under tall marsh plants.

8. Swamp forest (*Nyssa aquatica*, *Taxodium distichum*) *Nemobius carolinus*.

In the northern states *N. fasciatus fasciatus* is the most common species. It is found in all grass land except very wet marshy places where *socius* is found. This relation has been observed in New York and W. Virginia, Iowa, Colo., and the mountain sections of Virginia, and North Carolina. In Iowa where its distribution was studied more thoroughly, it attains greatest abundance in the blue grass (*Poa pratensis*) pastures, which are commonly found in small valleys. On the borders of marshes and near small sluggish streams it sometimes occurs with *socius* but does not extend into the wet undrained ground.

Near Raleigh, N. C. it was found during October and November 1930 in a few small areas on fertile flood plains along the Neuse River. These places were partially shaded and had a greater development of mesic grasses than is com-

monly found in the Piedmont. The dominant grass species were *Agrostis perennans*, *Muhlenbergia sylvatica* and *Poa pratensis*, all northern grasses approaching their southern limits here. In one large pasture on the river flood plain, *fasciatus* was found around the borders where there were trees and a few could be found near single trees in the open, but the rest of the area was inhabited by *socius*. In another place it was abundant among the above mentioned grasses on a high bank over the stream, where there were scattered trees and *Crataegus* bushes. In this small narrow strip there were almost no *socius* present but a hundred feet back from the stream in treeless portions of the field *socius* was common and *fasciatus* rare.

The most important environmental factors for *fasciatus* seems to be a good growth of grass without excessive moisture. It is tolerant to a degree of shade that does not interfere with the growth of grass and in the south may even demand shade.

N. socius, as recognized in this paper, is associated in the northern states with poorly drained grass land such as low prairies, pond and marsh borders, and low moist meadows and pastures. Restricted to such situations it has been observed in New York, Ohio, West Virginia, Iowa, Colorado, New Mexico, and in the mountains of Virginia and North Carolina. It was the only race found in the moist meadow along the stream at Pingree Park, Colo. at an altitude of over 9000 feet. In Iowa it could be found along small sluggish streams, often with *fasciatus*, and a few scattered individuals were observed in well watered lawns where *fasciatus* was dominant. It was found most abundant in a low undrained prairie bordering a marsh but not in the central area under the taller marsh plants.

In the Piedmont and Coastal Plain of North Carolina *socius* is more abundant and more widely distributed. It occurs in all short grasses and clovers such as those found in lawns, pastures and abandoned fields. In very sterile soils where grass grows sparingly, it is rarely found and *funeralis* takes its place. For some reason it can tolerate a much dryer habitat in the south, but as in the north it attains greatest abundance in low moist meadows and borders of marshes.

In the Piedmont and Coastal Plain of North Carolina *N. fasciatus tinnulus* is found in nearly all oak and pine woods except on the xeric sand ridges where no species of *Nemobius* has been found. It becomes most abundant in the more open

woods where some grass is growing. In the mountains the mesic forest type prevalent there is not favorable for it, and it becomes largely a forest border species. At Mt. Pleasant in southeastern Iowa it occurred where the woods were open enough to permit grass to grow. To sum up, the favorable factors for this race seem to be moderate moisture, a ground cover of dead leaves, the presence of grass or other low food plants, and possibly shade.

N. sparsalsus has only been found in salt marshes. When first found it was abundant out in the *Spartina* zone at the edge of the sound at low tide. At another time, during a high tide when the marsh was almost entirely flooded it was even more abundant among *Juncus* at the water's edge, apparently having been driven back by the water. No explanation can be offered for the restricted habitat of the species.

N. maculatus is strictly a forest species. Near Raleigh, N. C. it has been found only in the mesic type of forest which occurs there mostly along streams. It lives among the dead leaf ground cover on flood plains and hills but not in sloughs. In Iowa it seems to be somewhat more abundant along the edge of woods where there is grass as well as leaves on the ground, but occurs also in dense forest both on hills and flood plains. The species seems to be tolerant to a moderate range of moisture conditions but demands dead leaf cover or shade or both.

Specimens of *N. griseus griseus* were collected for the writer by E. M. Walker who writes that the species is extremely local in Ontario and that "it seems to prefer dry sandy pastures, covered with short grass, sedges (2 or 3 inches high), *Antennaria*, and the low-growing mosses of such situations." In this choice of a xeric habitat it is not unlike its southern relative.

N. griseus funeralis can tolerate more xeric conditions than any other species found in North Carolina. It has been found most commonly associated with broom-sedge (*Andropogon*) but not in very dense stands for this grass apparently serves as shelter rather than as a food plant. Where small grasses such as *Aristida oligantha* or small clovers like *Lespedeza* grow between clumps of *Andropogon*, it is found in greatest numbers but never becomes very abundant. A few have been found in crab grass (*Syntherisma*). It is very secretive in habits and seldom comes out from under the plants and for this reason has been a rare species in collections.

N. bruneri is a stream border species both in North Carolina and in Iowa. It is not found on small deeply shaded streams for it seems to demand at least a small amount of sunlight. It is most readily found on gravel bars, in company with *Paratettix* and *Gelastocoridae*. When disturbed it quickly jumps from the shelter of one rock to another. It has also been found on sandy banks where some grass or accumulated dead leaves furnish a shelter.

The near relative of the last species, *N. mormonius* is also found along streams, but in the arid west where it occurs such places are about the only situations where a species of *Nemobius* could be expected to exist.

N. cubensis is largely a marsh species, living both in fresh water marshes and in the *Juncus* zone of salt marshes. It is not confined to excessively wet places for it can also be found along stream banks and in other moist situations where it is protected by a thick covering of honeysuckle, high grass, or bushes. It has never been found by the writer on *Sphagnum* in company with the closely related *palustris*. Where patches of the moss grow along side of tall grasses *palustris* will be found in the former and *cubensis* in the latter.

N. palustris seems to be strictly an associate of *Sphagnum* and is found nowhere else. It can live in a jar and develop from the nymph to adult with no other food than *Sphagnum*. The eggs are deposited in the moss when they have a choice between that and soil.

The writer has not observed *N. ambiguus* in the field for it has not been found in North Carolina. Two lots of living specimens sent by T. H. Hubbel were accompanied by notes on their habitats. The habitat of the first lot from Dixie, Co. Fla., was described as "open sunny grove of *Quercus catesbaei* on whitish sandy soil, little undergrowth, much bare sand exposed, xerophytic habitat." The second habitat at the University of Florida Biological Station, Newman's Lake, Alachua Co., Fla., was described as "magnolia-oak-hickory-sweet gum hammock on sandy ridge, mesophytic habitat, forest floor covered with dead leaves and herbage, several inches of leaf mold over sandy loam." Hubbel also called attention to the fact that nymphs from the first habitat were grayish in color while those from the second were darker and more brownish in color. The most striking difference was in the color of the abdomen. Those from the sand ridge had a grayish white

ground color with several rows of paired, black spots in the median portion except the fourth segment which was entirely black. In the other lot the median area was sepia with only one paired row of black spots at the margins of the area. The remainder of dorsal area was of paler ground color with three paired rows of spots. The fourth segment was only slightly darker than the others. No striking difference was discovered between the adults of the two lots.

The nymphs of a second generation reared in the laboratory at Raleigh under identical conditions showed the same striking difference in color. This would indicate that there is some inherent difference between the crickets from the xeric habitat and those from the mesic environment. Further study might show that we have in this species another example of physiological differentiation taking place.

The most widely distributed species from the standpoint of plant associates is *N. carolinus*. The most important factor controlling its distribution seems to be moisture. Locally moist spots in an otherwise xeric habitat may have a colony of these crickets. It is an inhabitant of gullies, and seepage spots, in any plant community. With ordinary soil moisture it lives only under the protection of a dense cover of honeysuckle, thick bushes or matted grass. It is found most abundant in marshes and wooded ravines and sloughs. In swamp forest it is the only species found and in *Sphagnum* it is the only associate of *palustris*. In woods in southeastern Iowa it was abundant on level spots near the streams but on the slopes was replaced by *confusus*. Along open stream borders it is associated with *bruneri*.

N. confusus is another species confined to woods but it prefers the well drained slopes and uplands. It is never very abundant but is most often found in deciduous forest where it lives in the dead leaf ground cover. A few have been found in pine woodland, hiding under the bed of needles. Near Raleigh a large number were found in a patch of partridge berry (*Mitchella repens*) growing in an oak woods. Unlike *tinnulus* it is not partial to the more open grassy places and does not demand the more mesic forest type as in the case of *maculatus*. In southeastern Iowa it was found in oak forest, climax forest and sparingly near forest borders and under shrubby growths, always among dead leaves.

SUMMARY.

The discovery of specific characters in the male genitalia makes it possible to identify the males of the genus as readily as the females. Evidence furnished by such characters changes the status of *N. mormonius* Scudder from that of a subspecies of *N. cubensis* Saussure to a distinct species with closest relationship to *N. bruneri* Hebard.

N. fasciatus tinnulus new subspecies, is described and the conception of the status of *N. fasciatus fasciatus* (De Geer) and *N. fasciatus socius* Scudder is changed from that of a geographic one based on the relative length of the ovipositor, to a new conception of the above three subspecies based on certain characters in both sexes and which is correlated with physiological differences manifested in ecological distribution, seasonal history and song habits.

The song habits of the most of the species and subspecies found in the United States are described. Many species have a special song heard only when they are mating.

It has been found that the macropterous forms may remove their wings voluntarily.

The specialized proximal internal spine of the male hind tibia functions as an alluring gland. The formation of the spermatophore and the genital anatomy of both sexes is described.

In their ecological distribution the species of *Nemobius* are not bound by specific plant food relations, but are influenced by other factors which may confine them to certain plant communities. The observed environmental relations of all the species studied are described.

LITERATURE CITED.

- (1) Hebard, M. A Revision of the Genus *Nemobius* found in North America north of the Isthmus of Panama. Proc. Acad. Nat. Sci. Philadelphia, 1913, pp. 394-492.
- (2) Fulton, B. B. Physiological Variation in the Snowy Tree Cricket. Ann. Ent. Soc. Amer. 18: 363-383, 1925.
- (3) Allard, H. A. Variation in the Stridulations of Orthoptera. Ent. News, 23: 460-462, 1912.
- (4) Blatchley, W. S. Orthoptera of Northeastern America, pp. 1-784, Indianapolis, Ind., 1920.
- (5) Pantel, J. Notes Orthopterologiques IV, Sur quelques particularites de l'armure des pattes en sur l'avortement des ailes dans le genre *Nemobius*. Anal. Soc. Espan. Nat. 25: 47-58, 1896.
- (6) Wells, B. W. Major Plant Communities of North Carolina. N. C. Agr. Exp. Sta. Tech. Bul. 25: 1-20, 1924.

THE RELATION OF TEMPERATURE AND RAINFALL TO OUTBREAKS OF THE GRAPE LEAFHOPPER, *ERYTHRONEURA COMES* SAY

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While conducting investigations on the life history and control of the grape leafhopper (*Erythroneura comes* Say) in Erie County, Pennsylvania, the author had occasion to observe a series of outbreaks of this insect and to accumulate certain pertinent bits of information concerning the relation of weather factors to such outbreaks.

The particular series of outbreaks under observation occurred from 1920 to 1925 and were characterized by the leafhopper becoming increasingly abundant during the years 1920 to 1923, the outbreak reaching its climax in 1923, and the insect then decreasing in abundance in 1924 and 1925 so that it was not an economic factor during these two years. At this time, in collaboration with the Department of Entomological Extension of the Pennsylvania State College,* yearly surveys were made of the leafhopper population in representative vineyards in Erie County for the purpose of forecasting spraying data and for keeping records of the seasonal history of the insect in relation to weather fluctuations. These resulted in the assembling of detailed and accurate records of the activities of the insect in relation to the weather conditions obtaining for the period of years mentioned, and an attempt has been made in the following discussion to determine by the customary methods of statistical correlation the probable relation between these weather factors and the fluctuation in leafhopper abundance.

Since the relation of weather factors to insect outbreaks is hard to elucidate, owing to the difficulty in disentangling the

*The author wishes to acknowledge his indebtedness to Dr. D. L. Van Dine and Professor H. N. Worthley, of the Pennsylvania State College, and to Dr. T. L. Guyton, of the Pennsylvania Department of Agriculture, for assistance in the collecting of information relative to the habits and occurrence of the grape leafhopper in Pennsylvania and for the loan of their notes and data pertaining to this subject.

effect of abnormal weather not only on the insect itself, but also on its respective mortality factors (parasites, predators, disease, etc.), the author has followed as closely as possible the suggestions of Cook (1), 1927, regarding the collecting and analyzing of weather data in connection with insect outbreaks.

The question of parasitism and similar restraining factors may be dismissed by mentioning that during the four years of our observations in Erie County no insect parasites of the grape leafhopper were in evidence, nor were any permanent predators observed feeding on the leafhoppers during their breeding season. Johnson (2), in his studies in the Lake Erie region records one species of Hymenopterous parasite, *Aphelopsis* sp. and two predacious enemies, (*Anystis agilis* Banks and *Diaphnidia hamata* Van D.), but does not find any of them sufficiently abundant to be considered as control factors. Moreover, no fungus diseases were observed in sufficient abundance to be considered as restraining influences. Consequently weather conditions were assumed to be the foremost apparent factors active in determining leafhopper abundance during the period investigated and the data bearing on these factors was collected and analyzed as follows:

1. First a survey was made of the literature on leafhopper outbreaks in the Lake Erie region to ascertain the exact dates of such outbreaks and to obtain expressions of opinion from the various recorders concerning the possible causes of such outbreaks.

2. This particular investigation was confined to that section of the Grape Belt known as the "Lake Erie region" so that the data compared included only outbreaks of close geographic proximity and, as nearly as possible, the uniform weather conditions offered by a homogeneous geographical area. The Lake Erie region is regarded as that portion of New York, Pennsylvania, Ohio, Michigan and Canada bordering on Lake Erie, and the Chautauqua Lake region of New York.

3. All available meteorological data was secured from weather stations in close proximity to the outbreak centers for all years covered by and immediately preceding and following the outbreaks.

4. Composite climographs or hytherographs covering this data from said stations were constructed for the outbreak and "non-outbreak" years. These were compared with each other and with climographs representing normal years and an estimate formed of the relative importance of meteorological variations in the ecology of the grape leafhopper during normal, outbreak, and repression years.

5. The suspected meteorological factors were then directly correlated with figures representing the abundance of the species during the years in question and correlations were also made between the

deviations from normal of the weather factors and the leafhopper populations for the same periods.

6. The conditions found to pertain to the particular area and outbreak studied were then compared with the conditions of earlier outbreaks to determine if the abnormalities of the suspected meteorological factors occur at all times in correlation with outbreaks.

I. *A Survey of the Literature on Grape Leafhopper Outbreaks with Particular Reference to Those Occurring in the Lake Erie Region of the United States.*

Outbreaks of the Grape Leafhopper in the Lake Erie region have been recorded prior to 1900 by Fitch (3), 1861; Bethune (4), 1868; Saunders (5), 1871; Cook (6), 1874; Lintner (7), 1887-88; Lockhead (8), 1899 and 1900. None of these authors attempt to account for the reasons of these outbreaks. During the period 1899 to 1902 a series of definite outbreaks occurred in the Lake Erie region which were noted in 1902 by Felt (9). Hartzell (10) and Johnson (2) also note the occurrence of these outbreaks in their accounts of later outbreaks in 1910 and 1911. During the same period Fletcher (11) records an outbreak near St. Catharines, Canada.

Slingerland (12), 1904, makes one of the first contributions to our knowledge of the ecology of grape leafhopper outbreaks as follows:

"An outbreak of that common grape pest, the grape leafhopper, unprecedented in extent and destructiveness in the annals of New York has occurred in Chautauqua County during the past three years.

"Apparently the life pendulum of the grape leafhopper has begun its downward swing after an 'up' period of great destructiveness for two years, for last season they were not so numerous, although millions of them went into hibernation in the fall of 1902."

Gibson (13) notes its yearly abundance in Ontario in 1905 and 1906 and its continued abundance in the Chautauqua Belt is recorded by Symons (14) in the United States year books for 1906 and 1907. Its occurrence in the Canadian and United States portions of the Lake Erie grape belts is apparently not recorded in 1908 and 1909.

Gibson (15) in 1910 records its increasing abundance in the Ottawa region and Sill (16) notes that it was especially troublesome during the summer of 1910 in the North East district of Pennsylvania. In 1911 a serious outbreak is recorded for Pennsylvania by Johnson (17), and for New York by Hartzell (10).

In 1912, however, the leafhopper decreased greatly in abundance with regard to which Hartzell (18) comments as follows: "The winter of 1911-12 proved to be severe and hopes were entertained that this would cause a high mortality among the hibernating adults. However,

with the arrival of spring, the leafhoppers emerged from their winter quarters in great numbers and seriously injured the young foliage in many vineyards. . . . Considering the summer as a whole, considerable injury was done to vineyards; yet the injury was less than was expected because of the cool weather during June, July, August, and September. The weather conditions during this period were unusual as will be noted from the accompanying record.* The temperature for June was 106 degrees below normal, a daily deficiency of three to five degrees; July was slightly below normal; August gave a deficiency of 125 degrees, a daily average of four degrees; September temperatures were 59 degrees above normal or a daily excess of 1.7 degrees. In the months when growth is most active—May to September—there was a deficiency of 148 degrees, one degree daily. The amount of precipitation for May, August, and September was above normal, while June and July were deficient in rainfall. From the middle of July until the end of September there was an excess of rainfall and cloudy weather combined with low temperatures. There were only four clear days between July 15 and 31, and August had only one clear day, the others being cloudy or partly cloudy. The percentage of sunshine during August was 42 to 43 per cent below normal, while the rainfall was four inches, or 1-10 inches above normal, 40 per cent more than in a normal year. September had eleven clear days, 53 per cent of sunshine, 8 per cent departure from normal, and an excess of 0.13 inch or 4 per cent above the average. These abnormal weather conditions were unfavorable to plant growth and appeared to be especially detrimental to the grape leafhopper, since it prevented a second summer brood and apparently interfered with the health of the nymphs as well as the adults."

Johnson's (19) observations in 1911 with reference to periodic outbreaks of the grape leafhopper are as follows: "Periodically, however, some as yet unknown conditions seem to favor its multiplication and it spreads over wide areas. . . . Such conditions applied in the vineyards of Chautauqua County in the vicinity of Westfield, New York, during the seasons of 1901 and 1902, when many hundreds of acres of vineyards suffered greatly from the injury wrought by this pest. In 1903 the insect disappeared to a considerable extent and serious injury was again confined to limited areas until the season of 1910. The insect is now manifestly on the increase and during the past season (1910) spread through large blocks of vineyards. In fact, toward the latter part of the summer its presence in more or less destructive numbers was evident throughout the entire grape (Lake Erie) belt."

Johnson (2), in his bulletin on the life history of this insect also comments quite fully on the occurrence of leafhopper outbreaks in the Lake Erie Valley and he records, in much the same manner as Hartzell, the outbreaks of 1901 to 1904 and of 1910 to 1912. His explanation of the possible cause of the latter outbreak is as follows: "During 1911

*Monthly Met. Summary, 1912, U. S. Weather Bur., Buffalo, N. Y.

the injury wrought by the pest was greater than in preceding years, and the infestation was more widespread. The summer was unusually hot, and this resulted in the development of an almost full second brood which worked great injury to the vines late in the season. Immense numbers of adults went into hibernation, and large numbers of them emerged and made their appearance in the vineyards in the spring of 1912. Early in the season of 1912, on account of the presence of so many overwintering adults, there was every indication that the injury by this pest would be very great. There was an apparently normal development of the first brood of nymphs, and by the middle of the summer the injury in many vineyards was quite severe. Fortunately, however, the months of July and August were unseasonably cool. The low temperatures which prevailed during these two months so greatly retarded the development of the nymphs of the first brood that only a small percentage of the adults transforming from them deposited eggs for a second brood of nymphs. Hence there was not such a great increase in numbers of the insect during the latter end of the season of 1912 as there was at the end of the hot season of 1911."

From 1912 until 1920 the leafhoppers were apparently not seriously destructive in the Lake Erie grape belt. In 1916 Hartzell (20) writes as follows: "Only present in numbers sufficient to inflict damage over an extended area (in Chautauqua County) about once in eight or ten years. In other grape regions of the state they are more abundant each season, considerable injury occurring to the vineyards during shorter periods. It is necessary that such places (referring to hibernating quarters) be comparatively dry and free from inundation if the insects are to survive."

With regard to the particular outbreak to be analyzed in the latter part of this paper, DeLong (21), 1922, reports as follows: "The grape leafhopper has been a very serious pest in the Erie-Chautauqua grape area along the south-eastern shore of Lake Erie for many years During the seasons of 1920 and 1921 the hoppers have caused great damage to hundreds of acres of grapes in this section. . . . " Van Dine (22), in 1923, adds: "The high leafhopper infestation throughout the vineyards in the Pennsylvania section of the grape belt this season (1922) emphasized the need of control measures for this insect. . . . In the grape section under consideration there was an average infestation of 64.25 leafhopper nymphs per leaf in the maximum infested vines. . . . "

Ross (23) reports the abundant occurrence of this insect on the Canadian shore of Lake Erie during the same period and comments as follows on the possible influence of temperature and rainfall on yearly abundance.

"The adults went into hibernation in immense numbers and this spring they emerged in full force, the mild winter having had little if any effect in diminishing their numbers. By the time the grapes were in leaf, most of the graperies were literally alive with leafhoppers. During the period the overwintering adults were on the vines, there were several heavy washing rains. For example, on May 25th there

was a rainfall of 1.23 inches, on June 11th, 3.08 inches, and on June 17th, 1.38 inches. These rain storms reduced the number of adults to some extent (we found hoppers washed into the soil) but not to a sufficient extent to prevent a serious outbreak."

From this summary of the literature we may come to the following general conclusions:

1. Definite leafhopper outbreaks similar to the one observed by the author in 1920 to 1923 occurred in the Lake Erie Valley in 1901, 1902 and in 1911.

2. These outbreaks were invariably followed by periods of scarcity or low abundance.

3. Certain observers, particularly Hartzell, Ross and Johnson, have noted that low temperatures or excessive rainfall might have served as possible factors in reducing the infestation, following such outbreak periods.

Before proceeding to present the climatological data concerned with the particular outbreak under consideration, the author will briefly explain the general location and characteristics of the region referred to as the Lake Erie region.

II. *Definition and Climatological Characteristics of the Lake Erie Region.*

Erie County, Pennsylvania, where the author's studies were carried out, lies on the south-east shore of Lake Erie, about midway between Cleveland, Ohio, and Buffalo, New York. By the United States Weather Bureau it is classed as a part of the Lower Lake Region, which includes mainly that region west from Lake Ontario to Lake Michigan. The climate of Erie County is influenced largely by its proximity to Lake Erie because the lake lies directly in the path of the prevailing westerly winds. Consequently, the Chautauqua (N. Y.) and Erie County (Pa.) grape belts extending along the southern shore of Lake Erie for a distance of about 200 miles and inland from two to six miles have a mild climate due to the tempering influence of the Lake, which gives long mild autumns with unusually late fall frosts and winters which are less severe than elsewhere in the Lower Lake Region. Lake Ontario, to the north-east, also exerts a tempering influence, especially when cold waves, attended by rapidly falling temperatures, sweep down from Canada. During such times the difference

between the northern and southern shores of the Lake are sometimes as great as 20°.

The average temperature for Erie County is about 50°, with an average minimum of 39° and a maximum of 56°. The average annual precipitation is about 38 inches. During the summer months the average precipitation is somewhat greater than during the other seasons, but with this exception the distribution of precipitation is remarkably uniform.

III. *Seasonal History of the Grape Leafhopper with Relation to Normal Weather Variations.*

Before proceeding to analyze the effect of definite meteorological factors on the grape leafhopper it is necessary to briefly describe the normal occurrence of the various life stages of the insect with relation to the seasons of the year. This information was adequately obtained by Johnson (2) in his work in Erie County in 1911 and 1912 and is briefly summarized as follows:

"The grape leafhopper hibernates as an adult among accumulations of leaves and trash in vineyards, but mostly in adjoining woodlands, hedgerows and pastures. It becomes active during the first warm days of spring and commences feeding on the new growth of almost any of the plants with which it comes in contact. With the unfolding of the grape leaves there is a general migration of the insect to the vineyards. In normal seasons this takes place about the middle of May in the vineyards of the Lake Erie Valley. After feeding for a few days the leafhoppers mate and oviposition commences early in June. The average length of the egg stage is from eleven to fifteen days. The nymphs commence to appear on the under side of the leaves about the 20th of June, and by the end of the first week in July a large percentage of the first brood has hatched and is present in one of the several nymphal stages, of which there are five. The average length of the nymphal period is about twenty-eight days, but with many it varies from twenty to thirty-five days. A few newly transformed adults may be found in vineyards from about July 7th to July 12th.

"In normal seasons, however, the majority of the first-brood adults appear after the middle of July. Observations of the development of the insect indicate that if the nymphal period is lengthened by low temperatures during the month of July, the number of adults of the new brood that will mate and deposit eggs for a second brood is quite small; whereas, if high temperatures prevail during the early part of July, a large number of the nymphs are likely to develop rapidly and make their transformation about the middle of July. These early maturing adults mate and deposit eggs, and the resulting second brood of nymphs is quite large.

"By the early part of September most of the nymphs of both the first and second broods have transformed to adults, although a small number of nymphs may be found on the foliage until quite late in the fall. Toward the middle and latter part of September the adults commence to migrate from the vineyards and during warm, calm afternoons may be seen in swarms drifting through the air in an apparently aimless manner. They usually come to rest in adjoining woodlands or rough pasture lands. Here they remain more or less active during the warmer parts of the days of October, seeking the shelter of leaves and trash at night and during the cooler days, and becoming less active as the cold weather of winter approaches."

IV. *Seasonal Life History of the Grape Leafhopper with Particular Relation to Temperature and Rainfall During the Period 1920-1925.*

In comparing leafhopper abundance with weather conditions during this period the "leafhopper population" for each year is computed on the basis of the average number of nymphs per leaf from seven representative vineyards in Erie County. These vineyards were so located as to furnish this data from the western, central and eastern parts of the county and from the Lake-shore and inland grape growing areas. All weather data for Erie County was obtained from the United States Weather Bureau Station at Erie, this being a centrally located station with reference to the grape growing area of the county. The various comparisons made under this heading are discussed as follows:

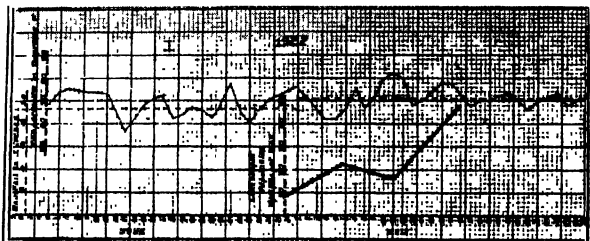
1. Variations in abundance and periodicity of the leafhoppers with relation to the temperature and rainfall immediately attending their seasonal activities.

2. Relation of monthly temperatures and precipitations, particularly those of the spring and fall, to leafhopper abundance during outbreak and repression years as determined by hytherographs and mathematical correlations.

1. *Variations in Abundance and Periodicity of the Leafhoppers with Relation to the Temperature and Rainfall Immediately Attending Their Seasonal Activities.*

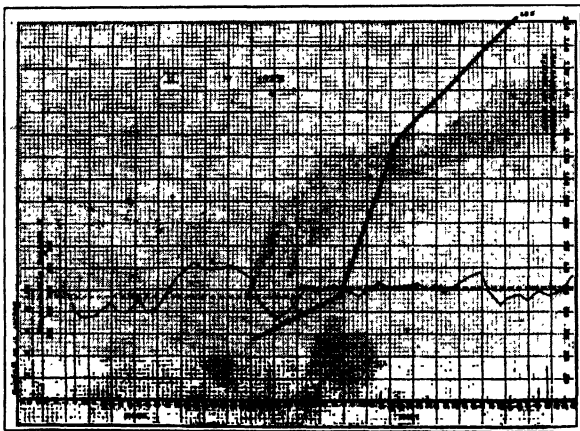
In Graphs I-IV, the yearly population counts for 1922, '23, '24, and '25 are compared directly with the daily mean temperature and precipitation records for the same periods, said periods commencing at the time the overwintering leafhopper adults commence laying eggs in the vineyards, which is approx-

imately June 1st for the Erie County region. Each population curve is constructed to cover the four points which indicate the dates on which the nymphs of the second, third, fourth, and fifth instars were found in maximum abundance rather than



GRAPH I. Relation of June and July Temperature and Precipitation to Leafhopper Population, 1922.

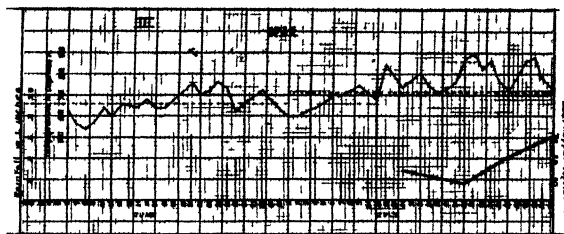
being based on counts made on the same dates of the series of years. In this way each point and intervening segment of the curve for a given year is directly comparable with the same



GRAPH II. Relation of June and July Temperature and Precipitation to Leafhopper Population, 1923.

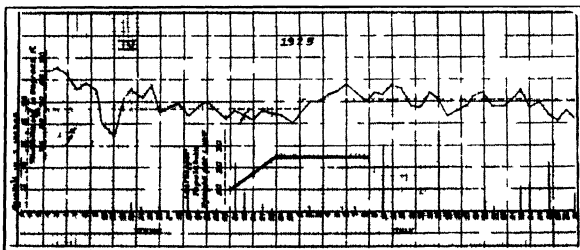
points and segments of the other curves of the series and the relative positions and inclinations of the comparable portions of each curve may be taken as indicative of the speed of development which took place during the particular season in question.

For example, in the curve for 1922, the second instar nymphs reached their maximum occurrences on June 30th, the third instar nymphs on July 6th, the fourth instar nymphs on July 11th, and the fifth instar nymphs on July 18th. In 1923 the



GRAPH III Relation of June and July Temperature and Precipitation to Leafhopper Population, 1924

dates for the maximum occurrence of the same series of instars were: second instar, June 26; third instar, July 6; fourth instar, July 12; and fifth instar, July 26. Comparing the increment in population in these two curves it can be seen that although



GRAPH IV Relation of June and July Temperature and Precipitation to Leafhopper Population, 1925

the transition from the second to the third instar was made in practically the same time interval and at approximately the same time of the year, the leafhopper population actually decreased during the interval between the third and fourth instars in 1922, while it increased greatly during the same period in 1923. Comparing the rainfall and temperature during the period immediately preceding the second instar counts (i. e., for the month of June) for the two years we see that the year

1922 was characterized by much more rainfall than was 1923 (i. e., the total June rainfall for 1922 being 2.1 inches and for 1923, 1.1 inches) while the comparative daily temperatures in excess of normal for the month of June for the two years are practically identical; i. e., 3.9° for 1922 and 3.8° for 1923. By applying this same method of analysis to the remaining portions of the curves for 1922 and 1923 and also to the curves for 1924 and 1925 we may conclude that in general the differences in leafhopper population between instars is more closely correlated with rainfall differences than temperature fluctuations and that in general dry years are accompanied by higher leafhopper populations than are wet years. This is remarkably well demonstrated in 1924, where the leafhopper population

TABLE I.

	1922	1923	1924	1925
1. First recorded appearance of overwintering adults in vineyards.....	June 2	May 31	June 9	May 29
2. Adults observed mating	June 2-15	May 31-June 6	June 9-15	May 30-June 5
3. First instar nymphs recorded.....	June 15	June 12	July 8	June 10

either actually decreased or increased only slightly from July 14 to July 31 during a period of increasing temperatures accompanied by continuous and heavy rainfall.

In addition to offering variations in rate of increase in population and actual numbers of leafhoppers per season, these same curves show distinct differences with regard to the time of year when the leafhoppers make their appearance. In the two curves just compared (i. e., 1922 and 1923) the various instars from the second to the fifth reached their periods of maximum abundance at practically the same time of the year (i. e., second instar between June 26-30, third instar, July 6, etc.). This would allow us to assume that the overwintering adults appeared in the vineyards and commenced ovipositing at approximately the same time during the spring, 1922 and 1923. This is supported by our observations of adult activities during these two years which are tabulated in the first two columns of Table I.

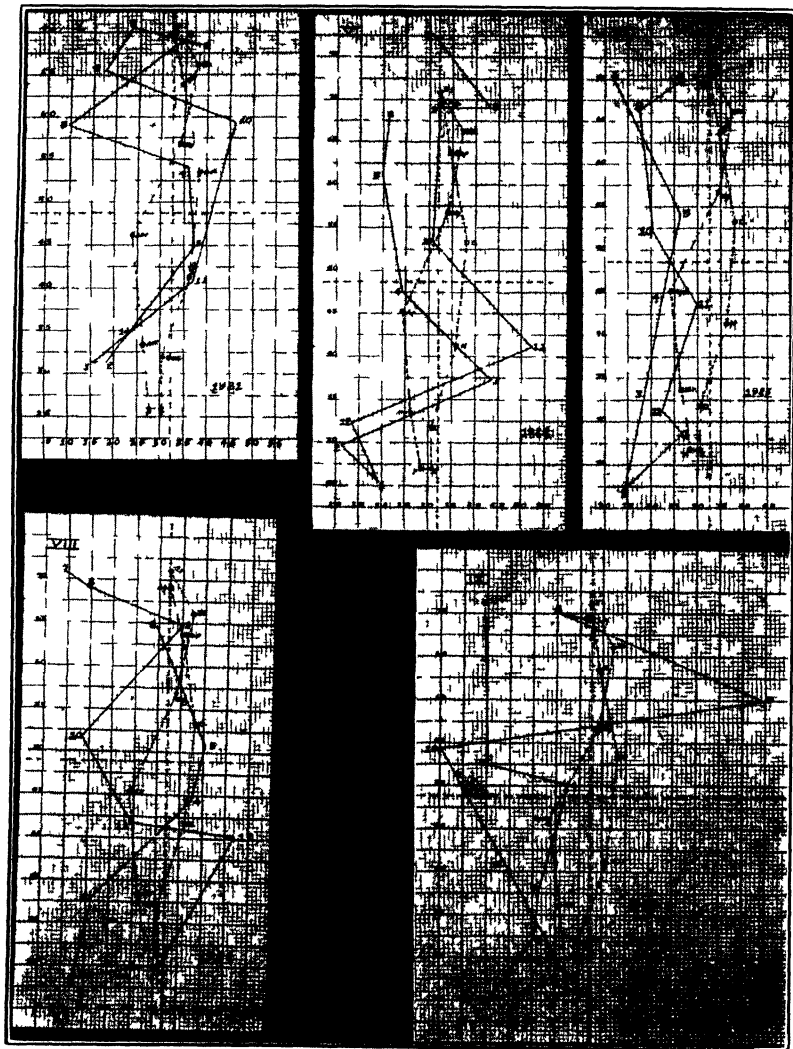
Comparing these data with those of 1924 and 1925, also included in the table, we see that these same phenomena were observed to occur somewhat later in these years, particularly in 1924, which were the years of greatest reduction in population. In 1924 the seasonal development of the leafhopper was so greatly delayed that most of the adults of the first generation did not develop until after August 10th, and the second generation failed entirely to develop. A similar situation during a year of repression has already been noted by Hartzell (18) in 1912. In 1924 the month of June showed a total precipitation of .8 below normal and in 1925 of 2.7 inches below. Hence, in these years, excess precipitation could not be regarded as a retarding factor with respect to time of appearance or rate of development. On the other hand, the average daily temperature deficiency for June, 1924, was 6.2° , thus furnishing a possible basis of explanation for the delay in development for that year. In 1925 the temperature for the month of June returned to more normal conditions, with an average daily excess of 4.8° , thus accounting for the almost complete return of the periodic events in the seasonal history of the leafhopper to their normal status.

Thus it appears that temperature may be a factor with regard to periodicity of occurrence, while rainfall influences the rate of increase and the establishment of a definite population. However, such an hypothesis, based on a cursory examination of comparative population, temperature, and rainfall curves must be more definitely established by the recognized methods of statistical analysis before it can be accepted. For this purpose we turn to an examination of the meteorological events of the entire year as expressed by climographs or hytherographs.

2. *Relation of Monthly Temperatures and Precipitations, Particularly Those of the Spring and Fall, to Leafhopper Abundance During Outbreak and Repression Years as Determined by Hytherographs and Mathematical Correlations.*

Graphs V-IX illustrate the yearly temperature and rainfall conditions pertaining in Erie County from 1921 to 1925, inclusive. The period 1921 to 1923 is characterized by increasing yearly populations and 1924 and 1925 by sudden and rapid declines. These diagrams are constructed so that the mean

temperature and total rainfall for each month of the year may be easily compared month by month. Also, to facilitate comparisons, each hytherograph is superimposed on one of lighter character (indicated in dotted lines) representing



GRAPHS V-IX Temperature-rainfall Hytherographs for Leafhopper Outbreak Period, 1921-1923, compared with those for Repression Period, 1923-1925

the normal temperature and rainfall records for each month of the year; and the yearly normals for both temperature and precipitation are indicated by heavy dotted lines crossing the hytherographs at right angles to each other.

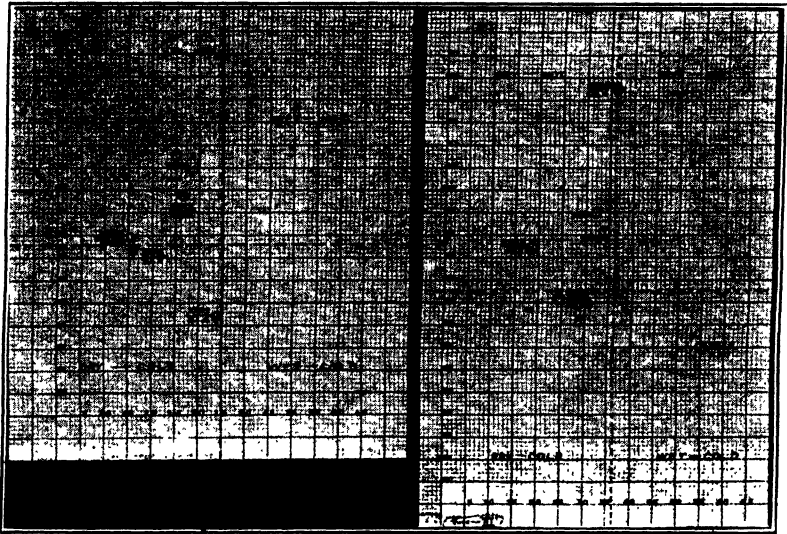
Owing to the fact that the period of most active increase in leafhopper population occurs usually in late June and July (see Graphs I-IV) the climographs are constructed to include one-half of each current year; i. e., the late summer, fall and early winter (July to December of the year preceding the outbreak or repression period to be analyzed), combined with the late winter, spring, and early summer (January to June) of the year under observation, dividing these two periods, however, between June and July rather than between March and April, because the developmental apex of the species occurs in July and is, as already shown in Graphs I-IV, activated to a large extent by the temperature and rainfall occurring in June and to a lesser extent by the same factors in the months immediately preceding June. Following the suggestion of Tehon (24), the ascending division of the hytherograph is called the "spring trend" and the descending division, the "fall trend." The two are separated in the diagram by omitting the connecting line between the point for July of one year and that for June of the following year.

These diagrams show that none of these years approaches the normal very closely, but when the spring and fall trends of each are compared respectively, certain similarities or differences are noted. For instance, in examining the spring trends of the years 1920 to 1925 we see that they become successively drier until 1924, during which year April and May show rainfall excesses of 1.3 and .65 inches respectively and, in addition, May and June evidence daily temperature deficiencies of 6.2° and 1.5° respectively. This, it will be recalled, is the first of the two years of reduced population. In 1925 spring conditions again return to the dry side of the hytherograph but the fall trend of the preceding year, 1924, evidences abnormalities both with respect to rainfall (i.e., July with an excess of .17 inches and September with 3.7 inches) and temperature (July with 1.9° daily deficiency and September with 3.4° daily deficiency). From this evidence we may roughly conclude that weather abnormalities, such as excessive moisture and low temperatures, during the breeding and ovipositing

period of the first generation in May and June or possibly of the second generation in July may exert a restraining influence. To a lesser extent perhaps would these same influences be a restraining factor in September when the insect commences its migration to hibernating quarters. To further test these assumptions, mathematical correlations between temperature deficiencies and rainfall excesses were made against the abnormalities of leafhopper occurrence as expressed in leaf population averages above or below the normal for the five-year period. Of these comparisons the most outstanding correlations were observed between the June and July 1922 and '23 rainfall and the corresponding excesses in numbers of leafhoppers, such correlations approaching perfection; i.e., .93 with a probable error of $\pm .051$ for June, and .96 with a $\pm .03$ P. E. for July. Correlations of lesser weight were likewise obtained for the 1923 and '24 period by comparing excess precipitation with deficiency in leafhopper population.

Now including May in this comparison, because it is the month when the overwintering adults come out of hibernation, the temperature-rainfall interrelations are graphically shown in Graph No. X. The normal mean temperature for Erie County for the May-July period is 64.3° as shown by the heavy dotted horizontal line and the average monthly precipitation is 3.48 inches as shown by the heavy vertical line. The point at which these lines cross represents the normal mean temperature and average monthly rainfall conditions for the three months' period. The temperature-rainfall combinations for each of the years under consideration (1921-25) are represented on the diagram by circled dots for the outbreak years and circled crosses for the reduction years. The year number and total leafhopper nymph population figure (at time adults of second generation commenced to appear) is placed to the left of each circle. The years of leafhopper outbreaks (1921-23) fall well within the dry-hot portion of the diagram, indicating that such conditions are favorable to leafhopper increase. Although the circles representing the two reduction years fall below the normal temperature line, they do not cross to the wet side of the diagram. The year 1924 does approach the wet side, however, showing that the cause for leafhopper reduction in this instance is truly an interrelation between temperatures lower than normal during the May-July period

and excess precipitation during the same interval, the latter apparently acting as an inciting factor in bringing about the beginning of such a reduction period. From this graph it appears also that temperatures of less than 64.3° F., accompanied by monthly precipitations in excess of 3.4 inches when they occur during the breeding and ovipositing season, are detrimental to the normal development of the grape leafhopper.



GRAPH X. Diagrammatic Correlation between Leafhopper Outbreak and Repression Years and Mean Temperature and Total Rainfall of the May-July Period, 1921-1925.

GRAPH XI. Diagrammatic Correlation between Leafhopper Outbreak and Repression Years and Mean Temperature and Total Rainfall of the September-October Period, 1921-1925.

The September-October or "prehibernation period" also apparently bears the same relation to yearly variations in leafhopper abundance in that a mathematical correlation of .83 (P. E., .269) was found between the September-October precipitations of the years 1920-1925 and leafhopper populations at the time of the maximum abundance of the second instar nymphs for the following season and a correlation of .77 (P. E., .198) between the same set of precipitation records and the fifth instar populations. Graph No. XI shows these relationships

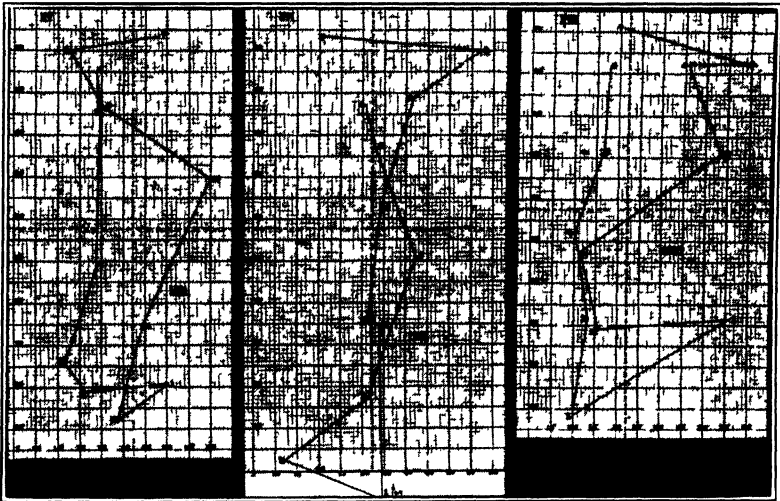
with reference to the September-October normals for the Lake Erie region and indicates that the relation at this time of the year is again closely connected with both temperature and rainfall abnormalities. The fall of 1923 was slightly lower in temperature than the preceding years (i.e., 58.5°) and the fall of 1924 slightly wetter (i.e., 3.64 inches), and these together incited the reduction or at least tended to further lower the reduction already brought about by the abnormal weather conditions already described for the spring of 1924. The fall of 1925 also adds further abnormalities, both with regard to deficient temperature (55.5°) and rainfall excess (5.56 inches), and tends to further still more the downward trend of leafhopper abundance. Here again the critical rainfall point appears to be in the general proximity of 3.5 inches, while the critical fall temperature of 58.5° , as shown by the year 1923, is a few degrees lower than the critical temperature already cited for the spring months (64.3°).

In both of the graphs just described the three points illustrating conditions during outbreak years and the two points illustrating years of abnormally low populations are too few in number to allow the drawing of accurate "trend lines." If such are approximated, however, they may be seen to run at right angles to each other and to intersect, in the case of the May-June-July graph, near the critical temperature point of 64° and in the September-October diagram slightly beyond the critical rainfall point of 3.5 inches.

To determine the effect of July temperatures and precipitations as "lag" factors in influencing leafhopper populations of the following spring, a diagram similar to Graph No. XI was constructed combining the July temperature and rainfall points for the years 1920 to 1924 with those of May and June of each following year. The graph was so similar to Graph X that it is not figured but it should be mentioned that the location of the yearly points with reference to the normal temperature axis tended to further substantiate the assertion already made that the critical spring temperature for the leafhopper is in the neighborhood of 64° F.

*V A Comparison of the Weather Conditions Described as
Influencing Leafhopper Populations of 1920-1925 with
Those of Other Outbreaks*

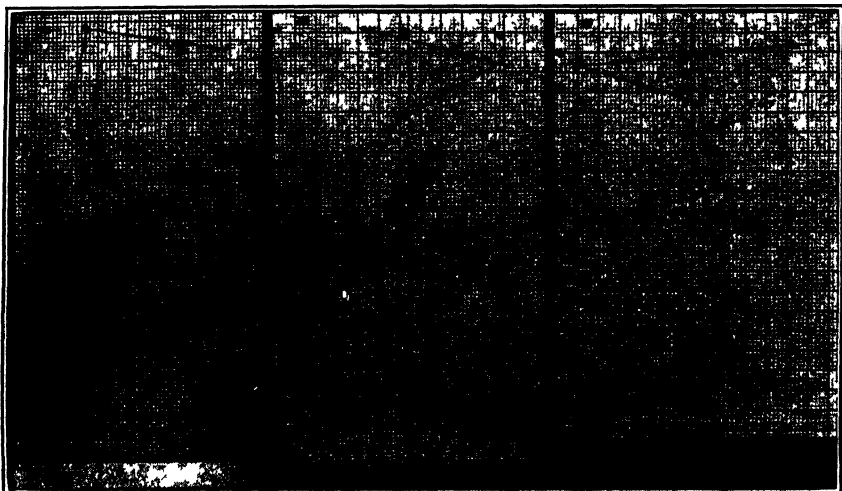
Owing to the great variation in the prevalence of parasites, predators and restraining influences other than weather factors in the different regions included in the normal geographic range of the grape leafhopper and because accurate data regarding these factors was unobtainable, it was decided to



GRAPHS XII-XIV Temperature rainfall Hytherographs for Leafhopper
Outbreak and Repression Period, 1901-1903

limit our comparison, for the present, to other leafhopper outbreaks and repressions occurring in the Lake Erie Region in years previous to the 1920-1925 period. Accurate accounts of two such phenomena are given by Johnson (2) and Hartzell (18), and these have already been discussed in the literature review at the beginning of this paper. The first of these consisted of a leafhopper outbreak commencing in 1901 and terminating in a repression year in 1903, the second outbreak occurred in 1911 and was followed by a period of greatly reduced abundance in 1913. Graphs Nos. XII to XIV illustrate in hytherograph form the weather conditions prevailing from 1901 to 1903. In Graph XII for the outbreak year of 1901 it may be seen

that the spring trend was characteristically dry during May and June, as was also the fall trend of the preceding year (1900) during September and October. The excess precipitation of July 1901 evidently came too late to cause any noticeable reduction because both Hartzell (10), and Slingerland (12), record them in immense numbers in the fall of 1901. The year 1902 (Graph XIII) was a "transition" year with a dry fall trend (1901) and a spring trend tending slightly toward



GRAPHS XV-XVII. Temperature-rainfall Hytherographs for Leafhopper Outbreak and Repression Period, 1911-1913.

excessive moisture. The reduction year (1903, Graph XIV) becomes exceedingly wet during the month of July and shows slightly heavier than normal precipitations in September and October. The spring trend supplies the climax to an unfavorable leafhopper period with abnormalities in both temperature and rainfall (i.e. mean temperature of June, 4° below normal and average precipitation, .8 inches above normal). The reduction brought about during this year was so effective that leafhoppers were not abundant in Erie County again until 1910, Johnson (2 and 19).

The second outbreak period (Graphs XV-XVII) which reached its maximum in 1911 offers a close parallel to the 1901-03 phenomena. The outbreak year (XV) opens the series

with a dry fall trend during August and September and an exceedingly dry spring trend for all months from February to June. Temperatures were about normal. The transition year (1912, Graph XVI) supplies a fall trend of slightly excessive rainfall (August, September and October) and a wet spring trend with the exception of June which crosses again to the "drier than normal" side. Temperatures during the fall trend were about normal although, as noted by Hartzell (18) January and February temperatures were excessively low. From June, 1912, however, exceedingly abnormal weather conditions prevailed (as noted by Hartzell (18), in which the subnormal temperatures of June, July, August and September were accompanied by excess precipitation, particularly in August, September and October. This year was so unfavorable that the leafhoppers failed to produce a second generation (Hartzell (18) and Johnson (2)).

CONCLUSIONS. .

The foregoing study, although including a consideration of a limited number of leafhopper outbreaks in a restricted geographical area, clearly indicates that the seasonal fluctuations in population, during the years studied (1921-25), were in all probability occasioned by weather conditions, particularly temperature and precipitation. The conclusions reached concerning the exact relation of these factors to the seasonal occurrence of the leafhopper may be summarized as follows:

1. Variation in abundance and periodicity of the leafhoppers with relation to temperatures and rainfall immediately attending their seasonal activities: In the establishing and maintaining of a definite seasonal population through the medium of the first generation, temperature bears a direct relation to the time of occurrence of the normal events in the seasonal cycle (e.g., emergence from hibernation, oviposition, and rate of development of the nymphal instars), high temperatures hastening these events and low temperatures retarding them. As has been demonstrated for the Codling Moth by Isely and Ackermann (25), and for other insects, the grape leafhopper requires a certain sum total of spring temperatures, above a definite mean, to successfully complete each of the periodic events of its seasonal cycle and until these necessary temperature requirements are supplied the development of the

first generation and the occurrence of subsequent generations are necessarily delayed. The mean effective or critical temperatures for each of these events can only be determined from laboratory experiments under controlled conditions, but our observations and analyses of outbreak and repression periods lead to the belief that spring temperatures exceeding 65° F. are necessary for the normal development of the insect and temperatures between 65° and 70° are necessary to insure a steady march of the periodic events of its seasonal cycle.

In this same connection, rainfall bears a direct relation to the ability of the leafhopper to establish and maintain itself in each of its periodic changes, light precipitation apparently favoring the successful establishment of high populations and excessive or heavy precipitation being detrimental to the same. Heavy precipitations exert a marked restraining influence on the adults emerging from hibernation, on their mating and oviposition activities, and on the early nymphal stages, particularly of the first generation.

2. The relation of monthly temperatures and precipitations, particularly of the spring and fall months, to leafhopper populations during outbreak and repression periods:

A comparison of climographs or hytherographs which represent the successive average monthly temperature and rainfall conditions during outbreak or repression years indicates that years of severe outbreaks are preceded by and associated with dry spring trends of the particular season concerned and dry fall trends of the preceding season. When the reverse weather conditions occur, periods of repression take place.

When these influences in the spring and fall trends are analyzed month by month by means of mathematical correlations, the month of June of the spring trend and the months of July, September, and October of the fall trend have the greatest significance.

Further comparison and correlation by means of meteorological graphs (i.e., X and XI) in which the temperatures and precipitations for the May-June and September-October periods are expressed in deviation from the normal reveals that leafhopper outbreaks occur well within the limits of the hot-dry portion of the diagrammatic analysis and that the repression years either fall well below normal temperature conditions or pass toward the wet portion of the diagram, or lie on trend lines inclining toward either or both factors. This method of

analysis further supports the assertion that spring temperatures (May and June) of less than 64° F. are unfavorable for leafhopper development and that these same temperatures are even more unfavorable when accompanied by monthly precipitations greater than 3.5 inches. Fall temperatures (September and October) below 58.5° F. are likewise detrimental and this condition is further accentuated when they are associated with rainfall in excess of 3.5 inches.

3. By a comparison of the weather conditions which were found to influence leafhopper fluctuations during the particular period studied by the author (1921-1925) with those of earlier outbreaks in the same region (i.e., 1901-03 and 1911-13) through a study of their respective nytherographs, it was found that the same principles underlying the 1921-25 outbreak and repression phenomenon applied to these earlier occurrences; i.e., outbreaks were, in general, associated with years having warm fall and spring trends accompanied by deficient rainfall, while repressions occurred during years of cool, moist spring trends, these being frequently further associated with subnormal temperatures and excessive precipitations during the preceding fall.

BIBLIOGRAPHY.

1. Cook, W. C., Unpublished lectures in Insect Ecology, University of Minnesota, 1927. (Also in Wardle, R. A., Problems of Applied Entomology, 1929.)
2. Johnson, Fred, U. S. D. A. Bul. 19 (Prof. Paper), 1914.
3. Fitch, Asa, Seventh Report N. Y. State Entomologist, 1861-62.
4. Bethune, C. J., Canadian Farmer, 1868.
5. Saunders, W., Ann. Report Ent. Soc. of Ontario, 1871-72.
6. Cook, A. J., Thirteenth Ann. Report Sec. of Agr., Michigan, 1874-75.
7. Lintner, J. A., Vineyardist, May, 1888.
8. Lockhead, W., 30th Ann. Report Ent. Soc. of Ontario, 1898; 31st Ann. Report Ent. Soc. of Ontario, 1900.
9. Felt, E. P., Bul. 37, U. S. D. A., Div. Ent., 1902.
10. Hartzell, F. Z., Y. Y. S. Exp. Sta. Bul. 331, 1910; Y. Y. S. Exp. Sta. Bul. 344, 1912.
11. Fletcher, J., 33rd Ann. Report Ent. Soc. of Ontario, 1903.
12. Slingerland, M. V., Cornell U. Agr. Exp. Sta. Bul. 215, 1904.
13. Gibson, A., Report Ent. Soc. of Ontario, 36, 1906.
14. Symons, T. B., Yearbook, U. S. D. A., 1906; Yearbook, U. S. D. A., 1907; Yearbook, U. S. D. A., 1908.
15. Gibson, A., Report Ent. Soc. of Ontario, 41, 1911.
16. Sill, W. H., Pa. Dept. Agr. Bul. 217, 1912.
17. Johnson, Fred, Report No. 17, Pa. Dept. of Agr., 1911.
18. Hartzell, F. Z., N. Y. S. Exp. Sta. Bul. 359, 1912.
19. Johnson, Fred, U. S. D. A. Bul. 97, 1911.
20. Hartzell, F. Z., N. Y. Dept. Agr. Bul. 79, 1916.
21. DeLong, D. M., Jl. Ec. Ent. 16, 1923.
22. Van Dine, D. L., Jl. Ec. Ent. 16, 1923.
23. Ross, W. A., 52nd Report, Ent. Soc. of Ontario, 1922.
24. Tehon, L. R., Ill. Nat. Hist. Survey, Bul. XVII, Art I, 1927; Ill. Nat. Hist. Survey, Art. IX, 1928.
25. Isely and Ackermann, U. of Ark. Bul. 189, 1927.

THE BLUEBERRY MAGGOT FROM AN ECOLOGICAL VIEWPOINT.

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It often happens that fundamental principles of ecology underlie problems of insect control, and in attacking an economic project the entomologist frequently finds himself working more or less in the field of applied ecology. Few instances in economic entomology emphasize broad ecological relationships more distinctly than does the blueberry maggot* problem.

Along the northeastern coast of Maine there has evolved during the past 50 or 60 years an industry which today furnishes an important source of livelihood for a considerable portion of the local population, and is said to produce an income of more than a million dollars annually. Yet this industry of producing blueberries has developed largely without scientific study or direction. The blueberry land is essentially wild land from which the forest cover has been removed, and it receives little or no care except for more or less haphazard mowing of the weed bushes and burning-over every third year. The blueberry plants have come onto this land entirely by their own powers of dissemination. In fact, the entire blueberry industry of northeastern Maine has evolved so naturally and blends so perfectly into the local natural economy that it gives the impression of being a step in a grand ecological succession rather than a product of commercialized agriculture.

CLIMATE AND TOPOGRAPHY.

The studies upon which this discussion is based were concentrated especially within the section of Washington County, Maine, lying approximately between the townships of Cherryfield on the west and Machias on the east, and extending some 20 or 25 miles north and south. However, in a general way the observations apply to the blueberry land of the costal section of Maine from Portland to Calais.

**Rhagoletis pomonella* Walsh; Diptera, family Trypetidae.

The climate of this section of Maine is characterized by long, severe winters and by short, mild summers, which, in comparison to the winter climate, seem quite warm. There is usually much snow during the winter months, and during the summer months there is frequent fog, mist, and rain. The monthly mean temperatures and precipitation are shown in Table I.

TABLE I.
NORMAL TEMPERATURE AND PRECIPITATION, EASTPORT, MAINE.*

Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
MEAN TEMPERATURE.												
20.4	21.5	28.9	39.0	47.7	55.1	60.4	60.7	55.8	47.5	36.7	26.3	41.7
MEAN MAXIMUM TEMPERATURE.												
48.	45	49	62	74	80	85	81	77	69	57	50	80
MEAN MINIMUM TEMPERATURE.												
-9	-5	5	20	33	41	47	48	39	29	15	-2	-13
NORMAL PRECIPITATION.												
3.92	3.35	3.83	2.84	3.01	2.97	3.08	3.00	2.78	3.55	3.32	3.74	39.39

The locality lies in the "Transition Life Zone" (4) and has a growing season of 120 to 150 days between killing frosts. (11.)

The blueberry land of this locality ranges in elevation from a little above sea level to an altitude of about 250 feet. It consists of moderately sloping to steep rocky hillsides, or of fairly level plateau areas. The typical "blueberry barrens" or "plains" are located on the plateau land.

The soil is mostly of a sandy nature, with a surface layer of dark colored organic matter. The terrain shows the effects of extreme glaciation. The surface of the soil is usually exceedingly rough, and is often studded with boulders and rock outcrops.

The forests that originally occupied this land have been removed, largely by lumbering operations, but in some cases,

*Data furnished by U. S. Weather Bureau Station, Eastport, Maine.

according to local tradition, forest fires were started deliberately to remove the trees and promote the growth of blueberries. The present vegetation of the blueberry land consists of rather irregular stands of blueberries, which usually grow from 6 to 12 inches high, and more or less numerous weed bushes, some of which may attain a height of 6 feet or more.

THE PROCESS OF BURNING OVER THE BLUEBERRY LAND.

From an ecological viewpoint as well as for horticultural reasons, the burning-over of the blueberry land is such an important feature of the blueberry economy that the process deserves somewhat detailed consideration.

On bright, calm days in early spring, after the snow leaves, but before the frost starts out of the ground, and while the blueberry plants are still thoroughly dormant, the surface litter is ignited (Plate II, A) and under favorable conditions fire sweeps the land clean of vegetation. (Plate II, B.)

On most of the better types of blueberry land the birch, willow, and alder "sprouts" are mowed during the fall preceding burning, and there is an increasing practice of spreading a light covering of hay (Plate II, A) on the land in the fall just after the sprouts have been cut. The hay increases the amount of combustible matter on the soil and insures more thorough destruction of the surface vegetation.

THE REACTION OF THE BLUEBERRY PLANT TO BURNING.

The above-ground parts of the blueberry plants are removed by the process of burning. The root system is unharmed by the fire, and the plant responds by a greatly accelerated vegetative growth during the summer immediately following the burn, but the plant produces no fruit during this first season. During the second summer a large crop of berries is produced. (Plate I, C, D.) After this first, abundant crop the production of fruit decreases each season until the yield becomes practically nothing; unless the land is again burned-over to rejuvenate the blueberry plants. In practice, the commercial blueberry growers have found that two crops of berries between burns are all that the average land will produce profitably, and the three-year cycle usually keeps the weed bushes fairly well under control.

THE EFFECT OF BURNING UPON THE BLUEBERRY MAGGOT.

It has often been observed that the blueberries of the first crop produced after the land is burned-over usually exhibit a considerably lower degree of infestation of maggots than does the second crop. This seemed to indicate that the heat produced by the flames passing over the blueberry land destroyed a considerable proportion of the puparia in their winter quarters in the soil. A careful investigation revealed the fact that the

TABLE II.

DEPTH OF PUPATION OF THE BLUEBERRY MAGGOT, CHERRYFIELD, MAINE, 1926.

Depth	Number of Puparia	Percent	Accumulated Percent	Depth	Number of Puparia	Percent	Accumulated Percent
Surface.....	78	1.08	1.08	13th half inch	0	0	.....
1st half inch	5,235	72.71	73.79	14th " "	0	0	.....
2nd " "	1,651	22.93	96.72	15th " "	0	0	.....
3rd " "	191	2.65	99.37	16th " "	4	.06	100.00
4th " "	31	.43	99.80	17th " "	0	0	.....
5th " "	7	.10	99.90	18th " "	0	0	.....
6th " "	2	.03	99.93	19th " "	0	0	.....
7th " "	1	.01	99.94	20th " "	0	0	.....
8th " "	0	0	.....	21st " "	0	0	.....
9th " "	0	0	.....	22nd " "	0	0	.....
10th " "	0	0	.....	23rd " "	0	0	.....
11th " "	0	0	.....	24th " "	0	0	.....
12th " "	0	0	.....	TOTAL.....	7,200	100.0	100.00

puparia of the blueberry maggot occur at a shallow depth; (Table II) but, even so, the puparia in their winter quarters under the surface of the cold, moist soil are effectively protected against injury, for the fire, which sweeps quickly over the land, is not sufficient to raise the temperature of the surface soil more than a very few degrees.

The process of burning-over the land exerts practically no direct effect upon the blueberry maggot. However, the reactions of the blueberry plant to the burn profoundly influence the behavior of the maggot. (Figs. 1 and 2.)

During the summer immediately following the burn there is a normal emergence of blueberry flies (Fig. 2, 1928) on the burned-over areas, and the absence of a crop deprives the

flies of berries in which to oviposit. This may be of little consequence on small patches, but where large areas are burned-over the flies must migrate considerable distances if they are

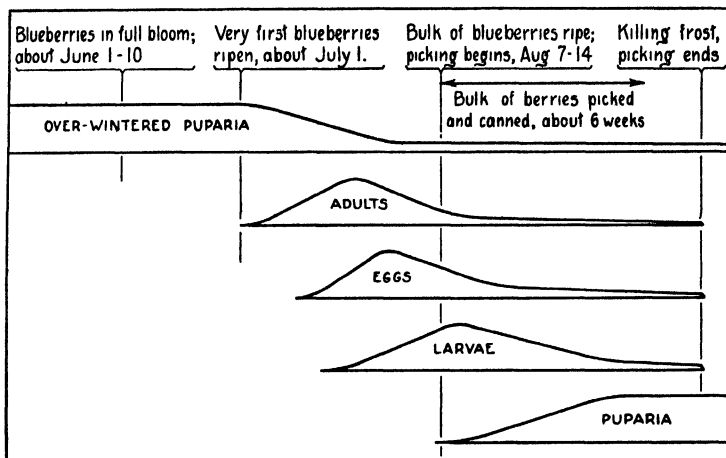


FIG. 1. Diagram showing life history of the blueberry maggot at Cherryfield, Maine.

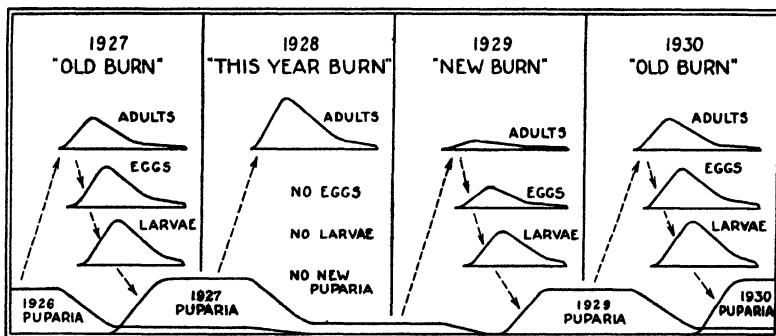


FIG. 2. Diagram showing the influence of burning upon the life history of the blueberry maggot.

to reach berries in which to oviposit. No maggots are produced on well burned land during the summer immediately following the burn (Fig. 2, 1928), with the result that the population of the species is greatly reduced.

The second summer following the burn is marked by the production of the first crop of berries, usually a heavy yield. The blueberry maggot has been "starved out" during the preceding season, and the beginning of the first crop year finds the population of the species at a low potential. (Fig. 2, 1929).

TABLE III.

SUMMARY OF EMERGENCE RECORDS OF ADULTS OF THE BLUEBERRY MAGGOT FROM FOUR CAGES OBSERVED FOR A PERIOD OF FOUR YEARS.

(Puparia formed in 1925.)

Year	Total Emergence	Per cent of 1926 Emergence
1926.....	1,113	.....
1927.....	219	19.68
1928.....	60	5.39
1929.....	6	0.54
TOTAL.....	1,398	

TABLE IV.

SUMMARY OF EMERGENCE RECORDS OF ADULTS OF THE BLUEBERRY MAGGOT FROM EIGHT CAGES OBSERVED FOR A PERIOD OF THREE YEARS.

(Puparia formed in 1926.)

Year	Total Emergence	Per cent of 1927 Emergence
1927.....	20,607	.....
1928.....	1,466	7.11
1929.....	124	0.60
TOTAL.....	22,197	

There are two important sources of reinfestation of the new crop of berries: (1) migration of flies from unburned areas, and (2) carry-over of puparia in the soil from the second preceding season. Migration of flies is undoubtedly important on small burns of a few acres and near the margins of larger burned-over areas. Under usual conditions the migration of flies probably is not a very important factor on solid burns of 10 or 15 acres or more.

A number of workers have noted that a portion of the puparia of the apple maggot remain in the soil for two years

before adults emerge. In the case of the blueberry maggot, the carry-over of the puparia in the soil for two seasons was found to be considerable, (Tables III, IV, V) and is probably sufficient to account for the infestation of the first crop of blueberries subsequent to the burn. It is interesting in this connection to note that from puparia that were formed in 1925, adults emerged in decreasing numbers during each of the four summers of 1926, 1927, 1928 and 1929.

TABLE V.

SUMMARY OF EMERGENCE RECORDS OF ADULTS OF THE BLUEBERRY MAGGOT FROM TWO CAGES OBSERVED FOR A PERIOD OF TWO YEARS.

(Puparia formed in 1927.)

Year	Total Emergence			Per cent of 1928 Emergence		
	Male	Female	Total	Male	Female	Total
1928.....	571	507	1,078	.....	.....	.....
1929.....	68	61	129	11.91	12.03	11.97
TOTAL.....	639	568	2,207			

With favorable conditions, the maggot population builds up rapidly upon the first crop of blueberries. During the second crop year the maggot population of the area reaches its maximum numbers. The large population of maggots, together with the somewhat reduced yield of blueberries, accentuates the percentage of infestation of the berries on the "old burn" areas.

Picking of the blueberries acts as an ecological factor retarding the increase of the maggot population, for many of the maggots are removed from the land with the fruit. The influence of picking is lessened, however, by the fact that the maggots begin leaving the berries soon after the harvest begins.

THE BLUEBERRY MAGGOT IN RELATION TO PLANT SUCCESSION.

The plant succession in this locality is typical of the north-eastern coniferous forest region. The principal stages in the succession are shown diagrammatically in Figure 3. If the forest cover is removed from the land, the vegetation usually reverts to the tall shrub association, which consists principally

of thickets of willow, alder, and birch. If the growth of these bushes is retarded by mowing and burning at intervals of two or three years, an artificial climax—the lowbush blueberry association—may be induced. The lowbush blueberry association consists largely of the lowbush blueberry, (*Vaccinium angustifolium*), often called locally low sweet blueberry, and the Canada Blueberry, (*V. canadense*), often known locally as

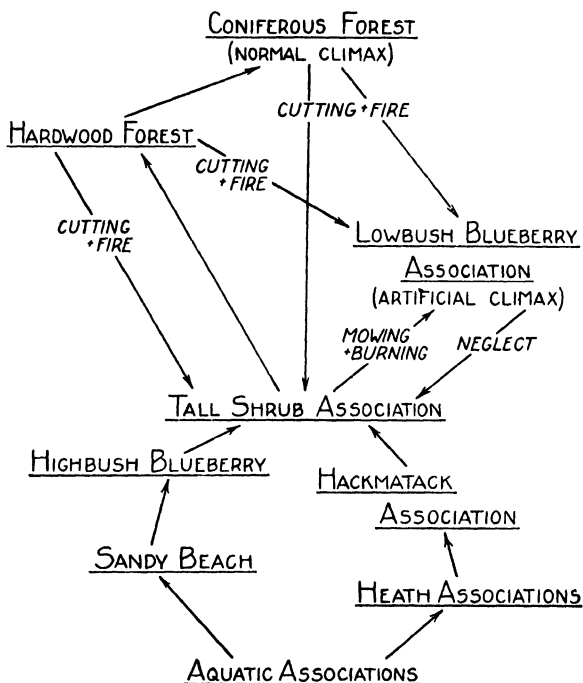


FIG. 3. Diagram showing the plant succession in relation to the lowbush blueberry association in northeastern Maine.

sourtop blueberry. Associated with these are other typical acid-soil plants such as the black huckleberry (*Gaylussacia baccata*), chokeberry (*Aronia melanocarpa*), bunchberry (*Cornus canadensis*), lambkill (*Kalmia angustifolia*), sweetfern (*Comptonia peregrina*), and sometimes the mountain cranberry (*Vaccinium vitisidaea minus*).

The population of the blueberry maggot varies considerably in different phases of the plant succession. The normal habitat

of the blueberry plant is typically a rather sparse undergrowth in the tall shrub association, and along the margins of the forest areas. Here the blueberry plants make slow growth, and comparatively few berries are produced. A considerable percentage of the berries may be infested by maggots, but, because there are relatively few plants and a scarcity of fruit, the maggot population on a unit area must remain low. A high percentage of infestation of the berries offers a favorable condition for parasitism, and the maggot population under such conditions tends to reach a rather stable equilibrium at a low potential.

When the trees and shrubs are removed from the area and the surface litter is burned off, the blueberry plants are greatly stimulated, the plants multiply and spread over the area; greatly increased yields of berries are then produced.

With the increasing numbers of berries present on the area, the parasites* of the blueberry maggot are at a disadvantage in finding infested berries in which to oviposit. Conditions favor the increase of the blueberry maggots, and the population of *Rhagoletis pomonella* on the area rises rapidly. However, the berries increase in numbers more rapidly than do the maggots, hence the percentage of infested berries decreases.

If the land receives continued care, a period arrives, after several years, when the blueberry maggot population of the area reaches a maximum (Plate IV, A). At this point the land is relatively free from weed bushes, so an excellent stand of blueberries is supported, and berries are produced in abundance. However, there still remains a sufficient growth of "sprouts" and sweetfern to furnish protection to the adult flies. If the culture is carried beyond this stage, and the sprouts and sweetfern are entirely removed from the land, there seems to be a tendency for the maggot population of the area to decrease, probably because of the excessive exposure of the adult flies to rain wind, and sunshine. Certainly, berries from blueberry land at its best development (Plate III, B) are seldom, if ever, found to have a high percentage of infestation.

If the blueberry land is neglected, (Plate IV, B) the sprouts are not mowed, and the land is not burned-over for a period of years, the vegetation soon reverts to the tall shrub association

**Opius melleus* Gahan was the most effective parasite of the blueberry maggot observed:

(Plate A). After a few years of neglect the yield of blueberries becomes insignificant. The percentage of berries infested by maggots may be very great, but the total population of blueberry maggots on the area is small.

SOME HOST-PLANT RELATIONSHIPS.

Rhagoletis pomonella Walsh was originally described (12) from a series of specimens reared in part from apple and in part from haws. The species has subsequently been reared from a considerable number of fruits, including cranberries (8), peach (5), pears (10), plums (3), Huckleberry (*Gaylussacia baccata*) (1), and from blueberries (*Vaccinium pennsylvanicum*, *V. canadense*, *V. vacillans*, (13) and *V. corymbosum* (6)). During the course of the investigations in Maine, the species has been reared from most of the berries found in the blueberry association, as listed below.

Blueberries:

**Vaccinium angustifolium* Kalm (m. a.)

**V. canadense* Ait. (m. a.)

**V. corymbosum* L. (m. a.)

Bunchberry:

**Cornus canadensis* L. (m. a.)

Chokeberry:

**Aronia melanocarpa* (Michx.) Britton (m.)

Huckleberry:

**Gaylussacia baccata* (Walt.) C. Kock (m. a.)

Mountain Cranberry:

Vaccinium vitisidaea minus Lodd (m.)

Dwarf Serviceberry:†

**Amelanchier bartramiana* Roem. (m)

Wintergreen:

Gaultheria procumbens L. (m.)

In the foregoing list there are several plants which may have considerable ecological significance. Huckleberries grow quite commonly in association with the blueberries, but usually are far less abundant than the blueberries. The huckleberries are not picked, but remain upon the plants until frost, and as they are frequently heavily infested with maggots these berries may in some places serve as an important reservoir of maggot infestation.

The bunchberry is frequently abundant on commercial blueberry land. This plant may flower and fruit every year whether the land is burned or not; hence the bunchberries are often abundant on blueberry land during the summer immediately following burning. This suggests that bunchberries may

*Plant identified by Dr. F. V. Covill, Bureau of Plant Industry, U. S. Department of Agriculture.

†Commonly known locally as sugar pear.

m. Species found infested by maggots, apparently *R. pomonella*.

a. Species from which adult flies were reared.

sustain the maggots on the burned-over land, and thus serve to increase the infestation of the new berry crop.

APPLE, HAW, BLUEBERRY RELATIONSHIPS.

From an ecological viewpoint the relationships of the forms of the apple maggot infesting apples, haws, and blueberries are most interesting. All of these fruits are infested by what is supposed to be a single species, *Rhagoletis pomonella*.

Specimens reared from blueberries are distinctly smaller in every stage than are those reared from apples or from haws. Although careful studies have been made, no definite morphological basis can be found for differentiating the two forms.

The difficulties encountered in rearing specimens of this species in confinement have prevented cross rearing and other experiments which might assist in solving the question of specific identity. In the absence of experimental rearing, other means must be used in examining the problem.

When small maggots are removed from blueberries and placed in ripe apples, the larvæ appear to feed normally. Some of the first-instar blueberry maggots transferred to apple successfully matured and formed puparia, but no adults were obtained. Of approximately 200 second-instar blueberry maggots transferred to apple, about 20 formed puparia, and 1 adult was obtained. The puparia and the adult were normal in size for the blueberry form.

Puparia were obtained from apple maggots which, in the second instar, were transferred to blueberries. No adults were obtained. The puparia were normal in size for the apple maggot. It is interesting to note that a single blueberry did not furnish sufficient food for an apple maggot, and two or more blueberries were usually consumed by each transferred apple maggot before it matured.

Evidently *R. pomonella* is a species native to the northeastern portion of the United States, where it undoubtedly infested haws, blueberries, and huckleberries before the introduction of apples by the white settlers.

That *R. pomonella* may exist upon apple independently of the blueberry, or vice versa, is suggested by the fact that the apple maggot is widespread and sometimes a serious pest in sections where blueberries and huckleberries are uncommon;

and huckleberries may be heavily infested in localities where the apple maggot is not an important pest.*

Comparable records made during the summer of 1927 indicate that the emergence of apple maggot flies averaged about seven days later than the blueberry maggot flies.

It is significant to note that there are three species of Trypetidae of the genus *Rhagoletis* (2, 9) which attack wild berries on the Pacific coast (*R. symphoricarpæ*† attacks the snowberry; *R. zephyria* and *R. tabellaria* infest the native whortleberries and blueberries), but apples are free from infestation in that region.

It seems probable that the blueberry maggot and the apple maggot exhibit an example of incipient species formation, and the present study tends to confirm the conclusion of Patch and Woods (7) that from an ecological viewpoint the two forms of *R. pomonella* are distinct and independent.

SUMMARY.

Few instances in economic entomology emphasize broad ecological relationships more distinctly than does the blueberry maggot problem. The entire blueberry industry of north-eastern Maine has evolved so naturally and blends so perfectly into the local natural economy that it resembles a step in a grand ecological succession rather than a product of commercialized agriculture.

The climate of northeastern Maine is characterized by long, severe winters, and by short, mild summers. There is usually much snow in the winter months, and frequent fog, mist, and rain during the summer.

The blueberry land consists of rocky hillsides, or of fairly level plateau areas, all of which show the effects of extreme glaciation. The forests that originally occupied this land have been removed. The present vegetation consists of rather irregular stands of blueberries from 6 to 12 inches high, and more or

*Through the co-operation of Dr. W. J. Schoene, a sample of huckleberries was obtained from Blacksburg, Va., which was found to be heavily infested by maggots apparently similar to *R. pomonella*. Prof. J. A. Berly kindly furnished samples of huckleberries from the mountains of Oconee County, South Carolina, which were also infested with maggots apparently similar to *R. pomonella*.

†Through the co-operation of Prof. D. C. Mote, Oregon State College of Agriculture, a sample of infested snowberries and a large series of specimens of larvae, puparia, and adults of *R. symphoricarpæ* were obtained from Corvallis, Oregon.

less numerous weed bushes, some of which may attain a height of 6 feet or more.

From an ecological viewpoint as well as for horticultural reasons, the burning-over of the blueberry land is an important process. The above-ground parts of the blueberry plants are removed by the process of burning, but the root system is unharmed if the burning is done properly. During the summer immediately following the burn, the plant responds by a greatly accelerated vegetative growth. During the second summer there is an abundant crop of berries. After the first crop the production of fruit decreases each season until the yield is practically nothing, unless the plant is again stimulated by the pruning due to the burning.

The process of burning-over the land exerts practically no direct effect upon the blueberry maggot. However, the reactions of the blueberry plant to the burn profoundly influence the behavior of the maggot. During the summer immediately following the burn there is a normal emergence of blueberry flies on the burned-over areas. Because of the absence of fruit on the recently burned land no maggots are produced during the season immediately following the burn, and this condition results in a great reduction in the population of *Rhagoletis pomonella* on the area.

The second summer after the burn, marked by the production of a heavy crop of berries, finds the maggot population at a low potential. There are two important sources of infestation of this new crop of berries, (1) migration of flies from unburned areas, and (2) carry-over of puparia in the soil from the second preceding season. Records made over a period of four years indicate that the carry-over of puparia in the soil for two seasons is considerable, and is probably sufficient to account for the infestation of the first crop of berries following a burn. Flies have emerged from puparia as long as four years after the larvæ entered the soil.

With favorable conditions the maggot population builds up rapidly upon the first crop of blueberries, and reaches maximum numbers on the second crop.

The plant succession in northeastern Maine is typical of the northeastern coniferous forest region. If the forest cover is removed the vegetation reverts to the tall shrub association. If the growth of these bushes is retarded by mowing and burning

at intervals of two or three years, an artificial climax—the lowbush blueberry association—may be induced.

The population of blueberry maggots varies considerably in different phases of the plant succession. The normal habitat of the blueberry plant is typically a rather sparse undergrowth in the tall shrub association, and along the margins of the forests. Here a large percentage of the berries may be infested by maggots, but because of the relative scarcity of berries the maggot population on a unit area must remain low. A high percentage of infestation of the berries offers a favorable condition for parasitism, and the maggot population tends to reach a stable equilibrium at a low potential.

As the development of the lowbush blueberry association is induced, the production of blueberries is greatly increased. The maggot population likewise increases, but somewhat less rapidly than does the yield of blueberries; hence the percentage of infested berries tends to decrease. If the land receives continued care, a period arrives, after several years, when the blueberry maggot population of the area reaches a maximum. If the culture of the land is carried beyond this stage, the maggot population tends to decrease.

If the land is neglected, the vegetation reverts to the tall shrub association, and the maggot population per unit area decreases.

The blueberry maggot has been observed in most of the berries found in the lowbush blueberry association, including nine species.

It seems probable that the blueberry maggot and the apple maggot exhibit an example of incipient species formation, and from an ecological viewpoint the two forms seem distinct and independent.

LITERATURE CITED

- (1) Britton, W. B. In Fifth Report of the State Ent. of Connecticut. Conn. Agr. Expt. Sta., 29th Ann. Rept. for 1905, p. 260, 1906.
- (2) Curran, C. H. In Canadian Entomologist 56: 62-63, 1924.
- (3) Herrick, G. W. Cornell Agr. Expt. Station Bul. 402, 1920.
- (4) Merriam, C. H. U. S. Dept. Agr., Biol. Surv. Bul. 10, 1895.
- (5) Miller, P. H. In Insect Pest Survey Bul. 9, No. 8, p. 325, Oct. 1, 1929.
- (6) O'Kane, W. C. New Hampshire Agr. Expt. Sta. Bul. 171, 1914.
- (7) Patch, E. M., and Woods, W. C. Maine Agr. Expt. Sta. Bul. 308: 77-91, 1922
- (8) Phillips, V. T. In Jour. New York Ent. Soc. 31: 113-155, 1923.
- (9) Plank, H. K. In Jour. Econ. Ent. 16: 99, 1923.
- (10) Porter, B. A. U. S. Dept. Agr., Tech. Bul. 66, 1928.
- (11) Reed, W. G. Advance Sheets 2. Atlas of American Agriculture, Part II. Climate, Section I, Frost and the Growing Season, 1918.
- (12) Walsh, B. D. In American Jour. Hort. 2: 338-343, 1867.
- (13) Woods, W. C. In Jour. Econ. Ent. 7: 398-400, 1914.

EXPLANATION OF PLATES.

PLATE I.

- A. Blueberries in last stages of infestation by *R. pomonella*, showing shrunken condition and holes nibbled through the skin by the maggots within the berries.
- B. Infested blueberries opened to show the maggots.
- C. Lowbush blueberry, *Vaccinium angustifolium*; first crop of fruit after plant was burned.
- D. Canada (Sourtop) blueberry, *Vaccinium canadense*; first crop of fruit after plant was burned.

PLATE II.

- A. Burning-over blueberry land. This land was well mowed and the hay on the right was spread during the preceding fall. On the left the fire is shown, creeping up against the slight breeze.
- B. Well burned blueberry land soon after burning, before the new growth of the plants has started.

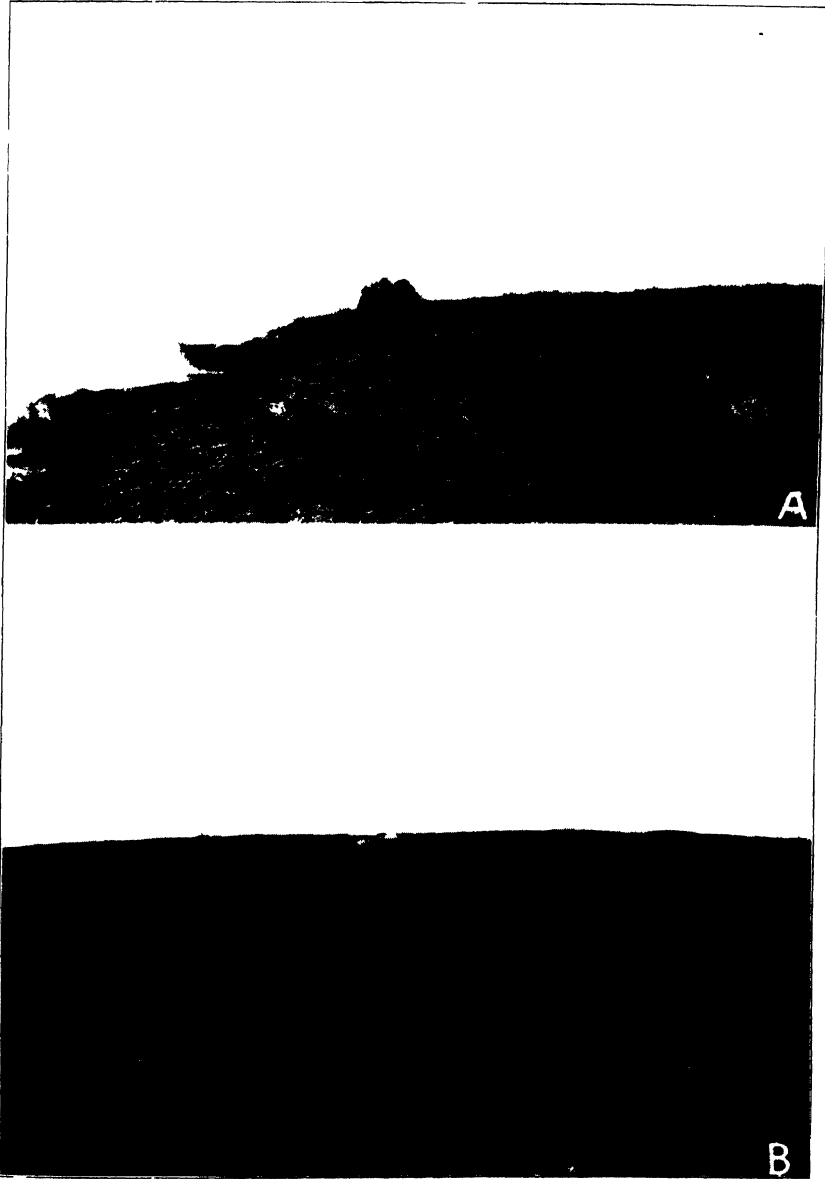
PLATE III.

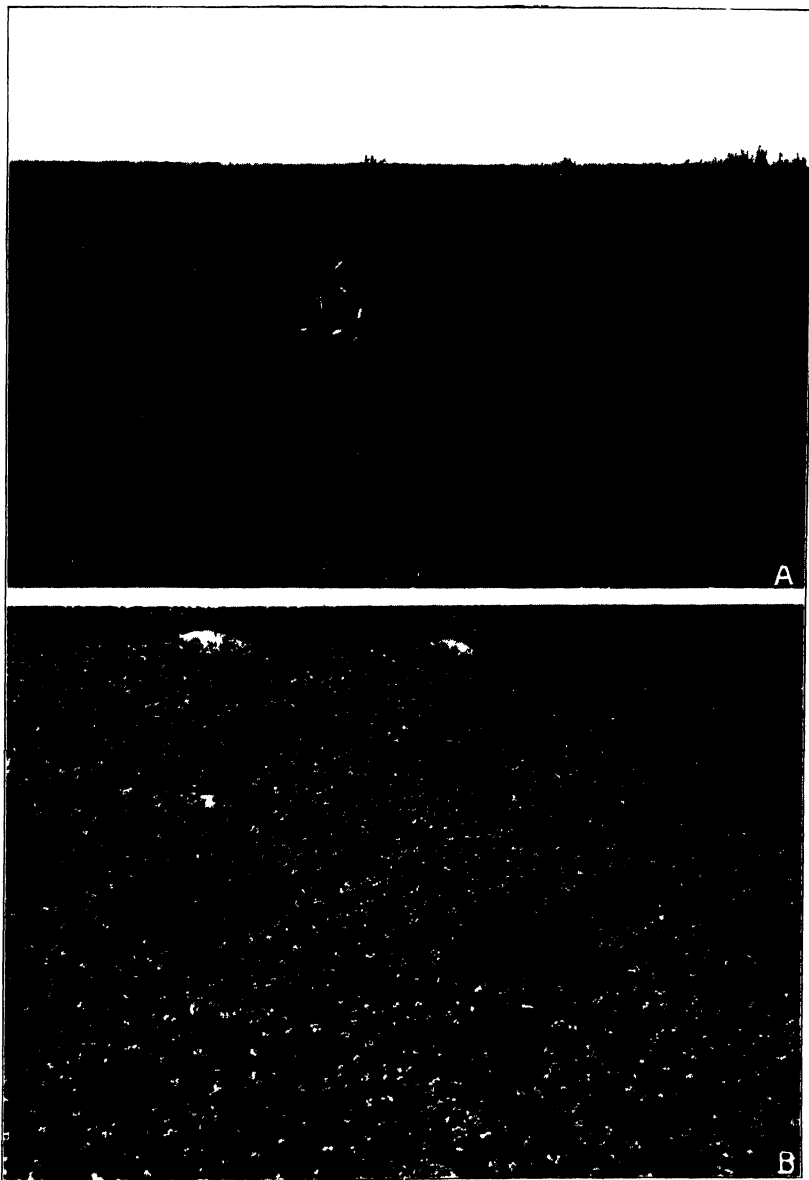
- A. Neglected blueberry land that has reverted to the tall shrub association. The land is being mowed (on the right) to induce the development of the lowbush blueberry association.
- B. The lowbush blueberry association at its best. The maggot population on this type of land tends to be somewhat lower than on land with a moderate growth of birch sprouts and sweetfern.

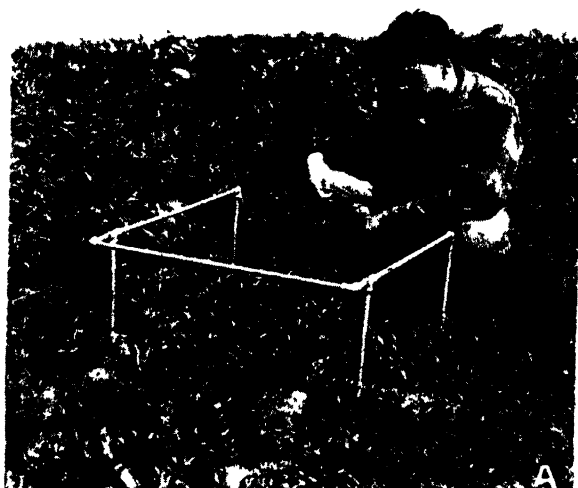
PLATE IV.

- A. Blueberry land of the type that supports the maximum maggot population per unit of area. There is an excellent stand of blueberries with sufficient sweetfern and birch sprouts to furnish protection to the flies. The man in the photograph is making a count of adults on a unit area.
- B. Excellent blueberry land that has been allowed to become somewhat too bushy for maximum crops of berries, or for maximum population of maggots per unit area. A high percentage of berries are infested here, and the maggot is very troublesome from a commercial standpoint.









STUDIES ON THE BIOLOGY OF PARATRIOZA COCKERELLI (SULC).*

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The potato psyllid was originally described and figured as *Triozza cockerelli* by Sulc (12) in 1909.

Patch (10) illustrated the wing and head of this form and mentioned the economic attention it had received in Colorado.

Crawford (4) described and illustrated this species, recorded the known range and food plants, and mentioned the fact that it sometimes became a pest of cultivated plants.

Compere (2) called attention to the injury to *Solanum capsicastrum*, caused by this insect. He (3) noted that *cockerelli* adults lived for one month in captivity; that egg-laying occurred three days after mating and continued for three days, the average number of eggs laid by the three females under observation being 36; and that in a hothouse the incubation period of eggs was 15 days. The nymphs passed through five instars, the duration of these varying from three to ten days; about 30 days were required from hatching to adult. Compere reported the broods as being continuous throughout the year at Sacramento.

Essig (5) recorded this as a minor pest in California; described the various life history stages, noting that the broods greatly overlapped; and that three to many broods occurred each year in California.

List (7, 8), recorded this as frequently becoming a tomato pest in Colorado and discussed control measures.

Richards (11) described an apparently new disease of potatoes, which he named "yellows"; this abnormality occurred during the summer of 1927 in Utah, Idaho, Montana, and Wyoming. The symptoms are described; the relationship of the nymph of *cockerelli* to this systemic disturbance is given.

*Contribution from the Department of Entomology, Utah Agricultural Experiment Station, in co-operation with the U. S. Bureau of Entomology.

†Associate Entomologist and advanced student in Department of Entomology, respectively.

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Binkley (1) recorded the occurrence of a destructive disease affecting potato in Colorado, thought to be associated with *cockerelli*; the disease seemingly was not produced by the feeding of the psyllids alone, but appeared to be a virus disease; nymphs hatched under sterile conditions did not produce the disturbance; the virus apparently does not pass through the egg.

Pack (9) recorded that the incubation period of *cockerelli* eggs was from 3 to 15 days and that the completion of nymphal development required from 14 to 17 days.

Recognition of the tomato psyllid as a serious pest, capable of affecting agricultural crops over a large area, followed the rather conclusive evidence obtained by Richards that the nymphs of *cockerelli* are closely associated with the development of the serious potato disturbance now known as psyllid yellows.

During the last three seasons a few areas in Utah have been affected by psyllid yellows, but the potato crop in general has not been affected in any way comparable to the serious damage of 1927. In most instances the damage to early potatoes has been much more severe than to the late potato crop.

The following life history studies were carried on in the entomological laboratory at the Utah Agricultural Experiment Station. Field studies and preliminary work on control were carried on during 1930 at the Davis County Experimental Farm at Farmington.

EGGS

The eggs of *cockerelli* are small, spindle-shaped to elongate-oval, usually shiny yellowish-orange in color, with a deeper orange on the pointed end supported by the short stipe. As fertile eggs develop and are nearly ready to hatch, the color in the basal end becomes a deeper orange, and the egg usually becomes somewhat flattened across the top, due to the flat shape of the contained nymph. Eggs are deposited on both upper and lower surfaces of the leaves and along the margins; a few have been found on the petioles and stems. Eggs are laid most abundantly on young apical leaves. Frequently a female will deposit a number of eggs in a row; in other cases she may scatter the eggs over the surfaces of two or more leaves during the course of a day. Ovipositing females usually deposited from five to 50 eggs during 24 hours; however, one female deposited 157 eggs during this interval of time. After

having laid 865 eggs between June 3 and June 26, this female escaped. During this period eggs were deposited daily except on the two days preceding the 24-hour period in which 157 were laid. During the 23 days of oviposition in captivity, this individual's daily average was 37.6 eggs.

The incubation period for eggs varied from three to nine days. The majority of the eggs hatched on the fifth and sixth days; however, during warmer weather a number hatched on the fourth day, while during cooler periods a number of eggs hatched on the seventh and a smaller number on the eighth day. Less than one per cent of the eggs hatched in less than 4 days, or required more than 8 days. Sometimes all eggs from one day's laying hatched on a given day, but usually they hatched over a period of three to four days.

Counts were made to determine the hatchability of a large number of eggs. It was observed that most of the eggs of some females were fertile, while those from other females would be largely infertile. Observations were made on 9,615 eggs, of which 7,989, or approximately 73 per cent, hatched.

In a few cases observations were made to determine the length of time a female could produce fertile eggs after the last mating. A male was placed with a female on July 31 and removed as soon as mating had been completed. Fertile eggs were deposited up to August 26; those produced thereafter were infertile. In a second case eggs deposited 24 days after mating were fertile and those produced thereafter were infertile. In a third instance all eggs deposited later than three days after mating were infertile.

NYMPHS

Just before hatching, the red eyes and sometimes the general body form of the nymph may be seen through the rather transparent egg shell. The head of the nymph is in the large apical end of the egg. The first evidence of hatching is the protrusion of the extreme anterior end of the body through the apical end of the shell, followed by the appearance of the pro-thoracic legs. At this place the nymph usually takes a short rest, after which it completely emerges. If the egg is on the upper side of the leaf, the movement during emergence partially telescopes the eggshell; while pulling the caudal end of the body from the egg, the shell is usually nearly straight-

ened out. After completing its emergence, the pale yellow and orange nymph creeps down the pedicel, moves around on the plant for a short time, then begins feeding. The time required for individual nymphs to completely emerge from the eggshell varied from 2.5 to 7.5 minutes, the average time for five individuals being 5.2 minutes.

After hatching from the egg the nymph passes through five instars. The duration of time in each stadium is somewhat variable. The length of time required in the first stadium varied from one to five days, the most frequent period being three days, with a great number requiring but two days. The average time required for 252 first-instar nymphs to complete this stadium was 2.76 days. Most of the nymphs that hatched from the eggs lived to complete the first-instar growth, but a high mortality resulted at the first ecdysis. The mortality among nymphs at the first molt was higher than for the four subsequent molts combined. The time required for completion of the second stadium varied from one to five days, the average time required for 186 nymphs being 2.44 days, or slightly less than the first-instar average. Third-instar development was completed in from one to four days, the average time required for 158 nymphs being 2.49 days. The variation in time required to complete the fourth stadium ranged from one to five days, the average time for 151 nymphs being 2.72 days, or nearly as long as the average for the first instar. More time was required in the fifth stadium than in any of the four preceding, the range being from three to nine days, with the average for 133 individuals that completed nymphal development being 4.87 days.

The length of time required to complete nymphal development varied to quite an extent, the greatest spread of all being in individuals maturing during June; one required 12 days to complete nymphal development while the development of another extended to the twenty-first day. Two individuals completed nymphal development in 19 days, but all others completed their development in 18 days or less, the minimum being 12 days. The length of time required for nymphal development in the laboratory varied with the time of year: The average number of days required during April was 16.9; during May, 17.2; during June, 15.1; during July, 13; during August, 15.45; during September, 16.1; and during October,

17 days. The average time required for the 133 nymphs to complete development was 15.35 days.

A second-instar nymph was observed to require 5 seconds for the outer cuticula to split down the back; 7 minutes were required for the nymph to completely emerge from the exuviae.

ADULTS

The coloration of newly-emerged adults changes noticeably during the first two or three days after the adult stage is reached. The newly-emerged adult is usually pale green or light amber in color. During the first 24 hours the body becomes a darker amber; during the second 24 hours the body becomes more of a brown, with a blackish cast appearing in many individuals, followed by a darker brown to black coloring, with pronounced characteristic white powdery markings. The dark coloration is obtained in from two to five days.

The sex was determined on 127 of the individuals that completed development during the life-history studies; 62 were males and 65 females, giving a sex ratio of approximately 1 to 1.

The adult *cockerelli* is active and easily disturbed but behaves well when confined in a small clip cage on a potato leaf. The type of cage used for adult psyllids is the same as that commonly used in this area for inoculating sugar-beets with curly-top virus by means of infective beet leafhoppers. This cage is made from a 4-dram homeopathic vial, the closed end being cut off, and the cut end of the bottle wall being flanged and covered with cheesecloth. A spring clamp and a metal disc to fit against the mouth of the bottle completes the cage. The adults feed, mate, and oviposit in the cages as readily, apparently, as they do when free on the plants. The cage was moved daily to a fresh leaf.

Under laboratory conditions the length of life varies greatly. Some individuals die within a day or two after emergence, while the longest record for a male was 64 days, and for a female 189 days. Knowlton (6) recorded one female that produced 1151 eggs. The female living the longest deposited 1352 eggs over a period of 179 days. Weeks before her death, the wings of this female were worn away until little more than stumps remained. One female lived 80 days and deposited 248 eggs, while another lived 71 days and laid 876 eggs. The total

number of eggs laid by 51 females that died in cages was 16,215, with an average of 318 eggs each. Nine females escaped while still ovipositing; up to the time of their escape, these individuals had deposited 3618 eggs, or an average of 402 eggs per female. The entire group of 60 females deposited 19,833 eggs, or an average of 330.55 eggs each.

The length of the oviposition period varied greatly, some females depositing eggs for a day or two only, while one female continued producing for 179 days; however, eggs were not produced each day of the oviposition period by most females. The average oviposition period for 58 females was 21.45 days. The preoviposition period varied with different females from five to 25 days, with an average of 10.1 days from emergence until the first eggs were produced. Most females under observation died within a few days after depositing the last eggs; however, one female lived on for 24 days. The average length of life after egg-laying ceased was 4.12 days. The average length of life for 53 males was 25.22 days and that of 56 females 34.4 days. Six females died without ovipositing.

Observations were made on 10 unmated females. Five of these deposited infertile eggs in numbers from 14 to 102, with an average of 49 per ovipositing female. The oviposition period ranged from one to 25 days, with an average of 12 days. Preoviposition periods for these females ranged from four to 47 days and post-oviposition periods from three to 29 days. The five remaining females failed to oviposit.

MATING

Just previous to mating the male becomes unusually active and apparently excited. He walks up to the side of a female and works his abdomen up and down against the body of the female in an attempt to place his abdomen under her wings. When the abdomens of the two individuals come together, mating occurs with the male and female standing with heads in the same direction. The male and female may both be standing on the surface of the plant or the male may cling to the side of the female. During the mating process the psyllids stand quietly together, the principal movement observed being movements of the antennæ. Mating usually lasts for a period of several minutes. Sixteen matings were timed; these con-

tinued over a period of from 1.5 to 14 minutes, with an average of 6 minutes. Mating was observed in one pair on the fourth day after emergence. In no instance was mating observed until after the adults had obtained the characteristic dark coloration.

FIELD OBSERVATIONS

Some interesting observations were made at the Davis County Experimental Farm during the season of 1930. Early potatoes began showing psyllid yellows by the end of the first week in June; by June 20 the earliest potatoes were in a serious condition, with most plants yellowed and with many plants producing aerial tubers. At this time adult psyllids were moderately abundant, cast fifth-instar skins were common, and 166 nymphs were found on the first plant examined. The potato hill was selected as the unit of comparison. On June 21, the plants on six hills of early potatoes were examined; the nymphal infestation ranged from 74 to 1086 on these plants, with an average of 456 to the hill. At this time large numbers of nymphs were in the fifth instar and adults were becoming rather abundant. One hill of late potatoes was examined at this time and only five nymphs were found. Four hills of early potatoes examined on June 28 showed a lower population, individual hills ranging from 72 to 263 nymphs, with an average of 149 for the four hills. On July 5, the plants from eight hills were examined, the number of nymphs ranging from 0 to 22 and with an average of four nymphs to the hill. Counts during the remainder of the summer ranged from 0 to 62, with an average of about six nymphs per hill. There was an overlapping of generations during the summer.

Sweepings were made with an insect net, to determine the abundance of adult psyllids at various times during the season. The number taken increased from June 20 to a peak on June 27 and then gradually decreased, so that during the latter part of July and during August only small numbers were taken at each sweeping. The unit of measurement used in estimating adult populations was 50 sweeps with a standard 15-inch American insect net.

The adult material collected on several occasions was examined to determine the sex ratio: 494 specimens were

males and 597 females, a ratio of approximately five males to six females.

Different observers have noted that during hot, sunny weather, the majority of *cockerelli* nymphs seek the underside of the leaf. Records were kept of the distribution of the nymphs on much of the material examined during June and early July; 14 nymphs were on the petiole, 146 on the larger stems, 1549 on the upper leaf surface, and 3251 on the lower surface of the blade. Shade appeared to be the limiting factor rather than position of the leaf. When psyllids are produced in the greenhouse during the cool part of the year, the nymphs become abundant on the upper surface of the leaf and also on the stem; they may be found feeding on any of the above-ground portions of a succulent potato plant.

LITERATURE CITED.

- (1) Binkley, A. M. Transmission studies with the new psyllid-yellows disease of solanaceous plants. *Science*, 70, No. 1825, p. 615, 1929.
- (2) Compere, H. *Paratrioza cockerelli* (Sulc). Calif. Mo. Bul. 4: 574, 1915.
- (3) Compere, H. Notes on the tomato psylla. Calif. Mo. Bul. 5: 189-191, 1916.
- (4) Crawford, D. L. A monograph of the jumping plant lice of the new world. U. S. Nat. Mus. Bul. 85, pp. 71-72, 1914.
- (5) Essig, E. O. The tomato and laurel psyllids. *Jour. Econ. Ent.* 10: 434-439, 1917.
- (6) Knowlton, G. F. *Paratrioza cockerelli* (Sulc). Bien. Rept. 1928-1930, Utah Exp. Sta. Bul. 220, p. 42, 1930.
- (7) List, G. M. Tests of insecticides. Ninth Ann. Rept. State Entom., Colo. State Ent. Cir. 26, pp. 40-41, 1918.
- (8) List, G. M. The tomato psyllid, *Paratrioza cockerelli* Sulc. Sixteenth Ann. Rept. State Ent., Colo. State Ent. Cir. 47, p. 16, 1924.
- (9) Pack, H. J. Potato psyllid. Utah Agr. Exp. Sta. Bul. 216, p. 21, 1930.
- (10) Patch, E. M. Psyllid notes. Maine Agr. Exp. Sta. Bul. 202, p. 231, 1912.
- (11) Richards, B. L. A new and destructive disease of the potato in Utah and its relation to the potato psylla. *Phytopathology*, 18, 140-141, 1928.
- (12) Sulc, K. *Trioza cockerelli* n. sp. *Acta. Soc. Ent. Bohemicae* 6, 105-108, 1909.

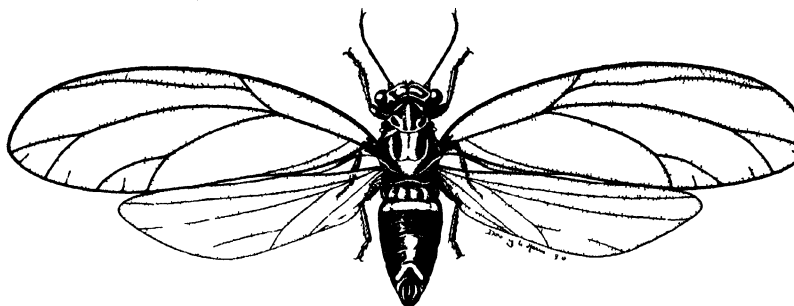


FIG. 1 - Adult male potato psyllid *Paratrioza cockerelli* (Sulc)

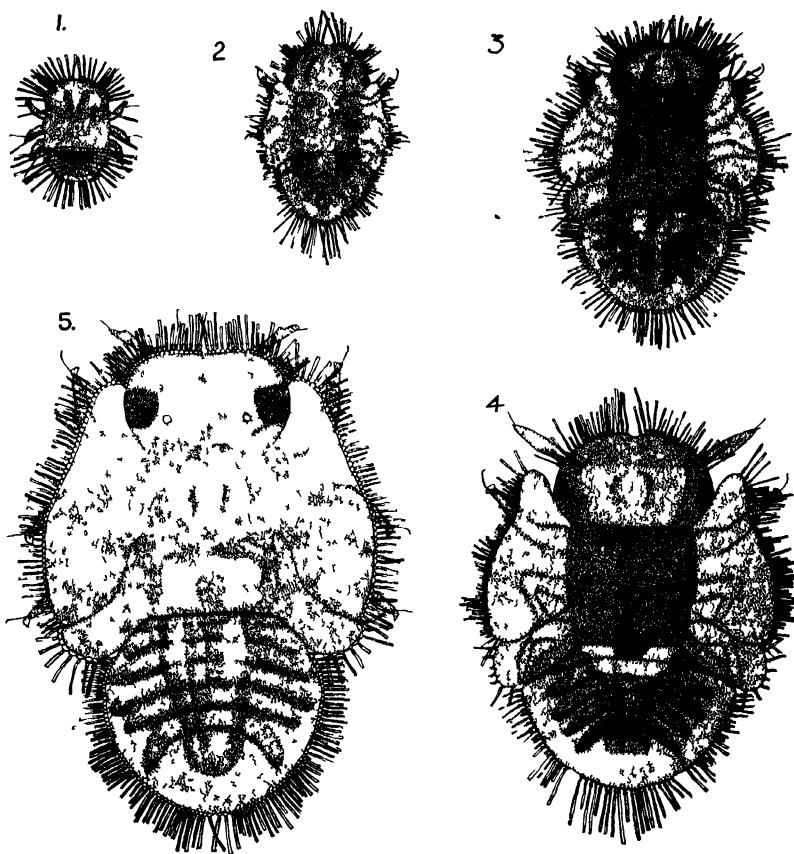


FIG. 2. The five nymphal instars of *Paratrioza cockerelli* (Sulc), showing relative size and shape

MACROCENTRUS ANCYLIVORA ROHR. AND M. DELICATUS CRESS. DISTINCT SPECIES.*

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and

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INTRODUCTION

The Braconid parasite *Macrocentrus ancylivora* Rohr. was described in 1923 by Rohwer (6) from specimens reared by Fink (3) from the strawberry leaf roller *Ancyliis comptana* Froehl. Stearns (7) proved in cross-breeding experiments that *Macrocentrus* bred from the strawberry leaf roller and from the larvæ of the oriental fruit moth were the same species. *Macrocentrus ancylivora* Rohr. has been recorded as a parasite of the oriental fruit moth from Virginia, Maryland, Pennsylvania, New Jersey, Connecticut, New York and Ohio.

Peterson and Haeuseler appear to have been the first to note the occurrence of a species of *Macrocentrus* other than *ancylivora* on the oriental fruit moth. Peterson called the senior writer's attention to the occurrence of a light colored brood of *Macrocentrus* at Riverton in the summer of 1927. These were identified later as *M. delicatus* Cress. This species has been recorded since 1927 as a parasite of the oriental fruit moth in New Jersey, Connecticut, and New York (1, 4, 5). Previous to 1927 it is recorded as having been reared from several different hosts (2). *Macrocentrus delicatus* Cress. was reared in considerable numbers from larvæ of the fruit moth collected in localities in the northern part of New Jersey from 1927 to 1930 and also from Riverton in the southern part of New Jersey in 1927, 1928 and 1929.

The occurrence of *M. delicatus* Cress. in considerable numbers on the oriental fruit moth at several localities in New Jersey every year from 1927 to 1930 led the writers to suspect this parasite was present on the fruit moth before 1927. Thirty

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specimens of *Macrocentrus* which had been reared from oriental fruit moth larvæ collected in different localities in New Jersey in 1925 and 1926, were found in the department insect collection. The specimens were labeled *M. ancylivora* Rohr. and the records showed they had been identified by a recognized specialist in that group of parasites. Six of the thirty specimens appeared to be *M. delicatus* and when submitted to Mr. R. A. Cushman of the National Museum they were verified by him as this species.

This past summer the writers visited a fruit moth laboratory in one of the eastern states. An opportunity was afforded to examine the *Macrocentrus* specimens on hand which had been reared from peach moth larvæ collected in that section in previous years. The specimens were labeled *Macrocentrus ancylivora* Rohr. and the records showed the source of identification was the same as that of the New Jersey material of 1925 1926. The majority of the specimens appeared to be *M. delicatus* although no careful examination was made of all the specimens. A number of cases of misidentification of species in several states similar to the above have come to the attention of the writers since this study was begun.

On several occasions one or two entomologists working on the oriental fruit moth and its parasites have expressed doubt that there are two species of *Macrocentrus* attacking the fruit moth. It was suggested that possibly *M. ancylivora* and *M. delicatus* reported from the fruit moth were color variations of the same species. During 1929 and 1930 life history studies were carried on at New Brunswick on *M. ancylivora* and *M. delicatus* using the larvæ of the oriental fruit moth as host. In addition several attempts were made to cross-breed the two species in the summer of 1930. It seemed worthwhile to present the results of these experiments at this time and to point out the difference in the two species.

METHODS

The cages used in the life history and cross-breeding work with *Macrocentrus* were cylindrical screen wire approximately 10 inches in diameter and 12 inches tall. The cages were set in pans of moist sand and the tops covered with a good grade of muslin. The parasites used in the breeding experiments were reared from oriental fruit moth larvæ collected in the field.

Each larva was placed in an individual vial so that when the parasite emerged there was no chance for it to come in contact with any other individual before being placed in the breeding cage.

The oriental fruit moth larvæ used in the breeding experiments varied in age from one to several days. They were obtained by inserting peach twigs in moth cages and as eggs were deposited the twigs were removed and set aside until the eggs had reached the black spot stage. Succulent twigs were collected in the field, the leaves removed, and placed with the twigs containing the black spot eggs. Upon hatching the larvæ entered the succulent twigs and to some extent the older twigs bearing the black spot eggs. The succulent twigs containing the newly hatched larvæ were transferred to the cage containing the parasites. The twigs were allowed to remain in the parasite cage from 24 to 48 hours, after which they were removed and placed on apples in battery jars with strips of corrugated paper. The larvæ came out of the twigs and entered the apples where they completed their growth. The battery jars were examined daily for larvæ that had spun cocoons in the straw paper corrugated strips. These were removed and placed one in a vial for further observations.

The apples used in the breeding work were collected as needed from a tree near the insectary. Succulent peach twigs were also collected as needed from young trees in an adjoining orchard. An effort was made to collect only twigs and apples free of larvæ. However, there was always the possibility that a few recently entered larvæ would escape notice and be included in the life history material. Since *Macrocentrus* parasitizes larvæ in all stages of development it is probable that a small percentage of the parasites obtained in the breeding experiments were from larvæ parasitized in the field before they reached the breeding cages.

LIFE HISTORY NOTES IN 1929 AND 1930

The life history study of *M. delicatus* was begun in the insectary at New Brunswick on July 13, 1929 and a similar study on *M. ancylivora* on July 26, 1929. The two studies were continued to the end of the season. Those larvæ that failed to complete their development in the fall were carried over the winter. Thirty-one individuals of *M. delicatus* and

110 *M. ancylivora* completed the life cycle from egg to adult emergence in the period from the time the experiments were begun in July to the end of the season. The average number of days for all generations in the cycle of *M. delicatus* was 32.2 and *M. ancylivora* 35.5.

Enough individuals of *M. ancylivora* survived the winter to enable us to continue the life history study of this species from the beginning of the season of 1930. Accordingly the first generation of *M. ancylivora* was begun May 14, 1930 using adults that had emerged in the insectary. The studies were continued throughout the season and a total of 735 individuals completed the life cycle. We did not succeed in carrying over the winter *M. delicatus*, therefore the life history study of this species was suspended until adults could be reared from larvæ collected in the field. The life history study of *M. delicatus* was resumed July 17, 1930. From that date to the end of the season 301 individuals completed their life cycle. The average number of days in the life cycle of *M. delicatus* and *M. ancylivora* from July 17 to the end of the season of 1930 was 35.6 and 35.2 respectively. A considerable number of individuals of both species emerged as late as November. These late emerging individuals required from 40 to 70 days to complete the cycle.

It had been observed that the light colored *Macrocentrus*, which were thought to be *delicatus*, were reared from larvæ collected in the field about the time second brood fruit moth larvæ were appearing. *Macrocentrus* individuals reared from larvæ collected early in the season of the first brood were of a dark orange color and were believed to be *ancylivora*. Careful watch was kept on the individuals emerging from one generation to the next in the life history studies of both species to see if there was any pronounced color change. There was no noticeable change. The light yellow *delicatus* produced light colored progeny from one generation to the next and the dark orange *ancylivora* likewise ran true in respect to color. There was a difference however in the proportion of sexes between the two species, *ancylivora* tended to produce more females than males whereas *delicatus* produced more males than females. Seventy-two per cent of the *ancylivora* were females in 1929 and 60 per cent females in 1930. The *delicatus* material ran 75 per cent males in 1929 and 74 per cent males in 1930.

ATTEMPTS TO CROSS-BREED THE TWO SPECIES

Attempts to cross-breed the two species were made beginning the latter part of July, 1930, when there was a maximum number of individuals of both species emerging in the life history and field collected material in the insectary. Four cages were made up similar to those used in the life history studies. Parasites that had recently emerged in individual vials were used in stocking the cages. July 22, 8 female *ancylivora* were liberated in cage 1; in cage 2, 7 female *delicatus* were liberated; cage 3 received 6 female *ancylivora* and 9 male *delicatus* and to cage four was added 5 female *delicatus* and 5 male *ancylivora*. Observations were made to see if any copulation took place. None was observed although copulation occurred in adjacent life history cages containing the two sexes of the same species. The following day batches of twigs containing recently hatched larvæ were inserted in each of the four cages. At the end of 48 hours the twigs were removed from the cages and placed in battery jars on apples to complete their growth. From this point on they were handled in the same way as described in the life history methods.

From the larvæ exposed to the unmated *ancylivora* females in cage one 13 males with the typical *ancylivora* markings emerged. From cage 2 (unmated *delicatus* females) there emerged 18 males with the typical *delicatus* markings. Cage 3 (*ancylivora* females and *delicatus* males) produced nine males and one female of typical *ancylivora* characteristics. Cage 4 (*delicatus* females and *ancylivora* males) produced seven male *delicatus*.

The above experiment was repeated July 30-August 1 with the following results. Cage 1 (unmated *ancylivora* females) produced 10 males and 1 female having the typical *ancylivora* markings. Cage 2 (unmated *delicatus* females) produced 18 males with the typical *delicatus* markings. Cage 3 (*ancylivora* females and *delicatus* males) produced 12 male *ancylivora*. No parasites emerged from the larvæ exposed to *delicatus* females and *ancylivora* males in cage 4.

August 5 to 8, 1930 a third experiment was run. *Ancylivora* females crossed with *delicatus* males produced 4 male *ancylivora*. The *delicatus* female and *ancylivora* male cross in the third experiment producing no progeny. A fourth experiment from

August 26 to 29 produced ten *delicatus* males from a cage containing *delicatus* females and *ancylivora* males. A fifth and last experiment was set up September 7 to 10. *Ancylivora* females and *delicatus* males produced 4 *ancylivora* males. *Delicatus* females and *ancylivora* males produced 4 *delicatus* males.

The adult *Macrocentrus* used in the five attempts at cross-breeding during July, August and September, 1930, were carefully labeled and preserved. Likewise the progeny resulting from these attempts at crossing were carefully labeled as to source. Examination of the material showed that those females possessing *delicatus* characters produced only males with *delicatus* characters whether the females had access to males having *ancylivora* characters or not. Also the females possessing *ancylivora* characters produced only males with *ancylivora* characters with two exceptions. In the *ancylivora* female and *delicatus* male cross in the first experiment 13 males and 1 female *ancylivora* were produced and the unmated female *ancylivora* in the second experiment produced 10 males and 1 female *ancylivora*. On the face of the evidence it would appear that *M. ancylivora* is deuterotokous. However it will be recalled that the twigs and apples used in rearing the larvæ were collected from trees where peach moths and parasites were prevalent. Therefore the two female *ancylivora* probably came from young and already parasitized larvæ present in the twigs or apples at the time they were collected. All of the parasites used in the attempts at cross-breeding and the progeny resulting were submitted to Mr. Cushman who wrote that the determinations appear correct.

MORPHOLOGICAL DIFFERENCES

Mr. R. A. Cushman identified the *Macrocentrus* material sent to the U. S. National Museum from the New Jersey Experiment Station since 1927. The following characters for distinguishing *delicatus* from *ancylivora* were supplied by Mr. Cushman in a letter to the senior author.

"In *ancylivora* the stigma is relatively shorter and broader with the radius not far beyond the middle and it is more or less stained with a dark color. In *delicatus* the stigma is long and narrow with the radius far beyond the middle and it is entirely pale straw-colored. As a checking character one might use the

number of joints of the antennæ; in *ancylivora* there are 41-46 joints and in *delicatus* 51-56 joints."

Besides the foregoing characters the writers, in handling hundreds of specimens of both species in the insectary, have observed other differences, some of which were used for separating live material in the insectary. The ground color of the body of *delicatus* is pale straw-colored with the dorsal aspect of the thorax and abdomen in some specimens dark. The ground color of *ancylivora* is dark orange or brownish red. This agrees in general with Cresson's "pale honey-yellow" for *delicatus* and Rohwer's "ferrugineous" for *ancylivora* in the original descriptions. The antennæ of *delicatus* are longer than *ancylivora* and in *delicatus* the points of articulation of the joints of the antennæ are darker than the rest of the joint, giving the antennæ a beaded appearance when observed with a hand lens or the naked eye. This beaded effect is not evident in the antennæ of *ancylivora*. When specimens of *delicatus* are killed and mounted on pins the tips of the antennæ tend to curl so as to form one or more loops. The curl at the tips of the antennæ of *ancylivora* is not as pronounced as that of *delicatus*.

The points used in separating two species rapidly in the insectary were (1) the general color—pale yellow in *delicatus* and dark orange in *ancylivora*; (2) appearance of antennæ—beaded in case of *delicatus* and hair-like in case of *ancylivora* and (3) color and shape of stigma—pale yellow, long and narrow in *delicatus* and dark brown to black and short and broad in *ancylivora*. The length and number of joints in the antennæ and the position of the radius in respect to the stigma were used for further checking after the parasites were mounted.

Figures one to four, Plate I, are illustrations of the two sexes of *M. ancylivora* and *M. delicatus*. The authors are indebted to Mr. B. Landis of Ohio State University for assistance in the preparation of the drawings.

SUMMARY AND CONCLUSIONS

The parasite *Macrocentrus ancylivora* Rohr. was first reared and described in 1923 from the strawberry leaf-roller. Later it was reared from larvæ of the oriental fruit moth. Another species identified later as *M. delicatus* Cress was first noticed by Peterson and Haeussler in 1927. Both species were found

parasitizing the larvæ of the oriental fruit moth in New Jersey from 1927 to the present and there is evidence that *M. delicatus* was active as a parasite of the fruit moth before 1927.

Different determinations as to species have been made of *Macrocentrus* specimens reared from the oriental fruit moth and several entomologists carrying on investigations of this pest and its parasites have expressed doubt that there are two species of *Macrocentrus* attacking the fruit moth. It has been suggested that possibly what appeared to be two species was merely color variations of the same species.

Life history studies carried on in 1929 and 1930 and attempts to cross-breed the two species in 1930 produced data which seem to prove that *Macrocentrus ancylihora* Rohr. and *Macrocentrus delicatus* Cress. are two distinct species parasitizing the larvæ of the oriental fruit moth. Morphological differences between the two species are discussed.

LITERATURE CITED.

- (1) Driggers, B. F. 1929. Some Parasites of the Oriental Peach Moth in New Jersey. Jour. N. Y. Ent. Soc., Vol. 37, p. 171.
- (2) Driggers, B. F. 1930. Some Studies on the Larval Parasites of the Oriental Peach Moth (*Laspeyresia molesta* Busck.). N. J. Agr. Expt. Station Bulletin 510.
- (3) Fink, D. E. 1926. The Biology of *Macrocentrus ancylihora* Rohwer, an Important Parasite of the Strawberry Leaf Roller (*Ancylus complana* Froehl.). Jour. Agr. Res. 32: 1121-1134.
- (4) Garman, P. 1930. The Oriental Peach Moth in Connecticut. Conn. Agr. Expt. Station, Bulletin 313.
- (5) Haeussler, G. J. 1930. Parasites of the Oriental Peach Moth *Laspeyresia molesta* Busck., in North America. Jour. Agr. Res. 41: 365-377.
- (6) Rohwer, S. A. 1923. A New *Macrocentrus* Reared from the Strawberry Leaf Roller. Proc. Ent. Soc. Wash. 25: 168.
- (7) Stearns, L. A. 1928. The Larval Parasites of the Oriental Peach Moth (*Laspeyresia molesta* Busck.) with special reference to the Biology of *Macrocentrus ancylihora* Rohwer. N. J. Agr. Expt. Station, Bulletin 460.

EXPLANATION OF PLATE.

- Fig. 1. Male of *Macrocentrus ancylihora*.
- Fig. 2. Male of *Macrocentrus delicatus*.
- Fig. 3. Female of *Macrocentrus ancylihora*.
- Fig. 4. Female of *Macrocentrus delicatus*.

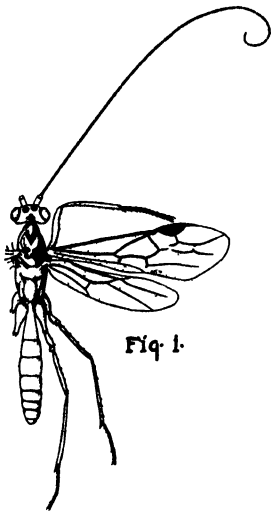


Fig 1.

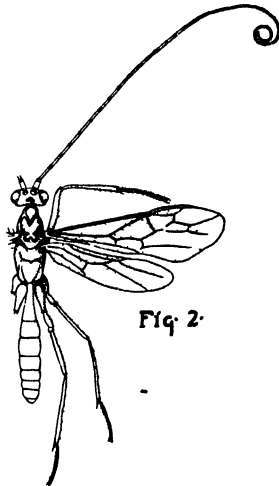


Fig 2.

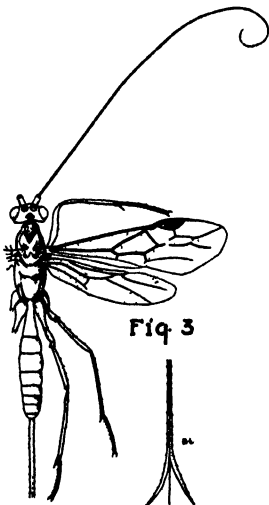


Fig 3

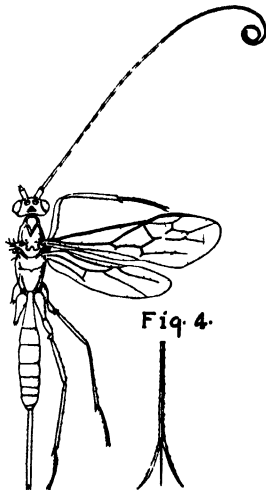


Fig 4.

THE MAGNOLIA SCALE (NEOLECANIUM CORNUPARVUM THRO.).

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Cornell University.

It is always of great interest to watch the "ups and downs" of insects—to observe the enormous abundance of a certain species over a period of years and then note the gradual subsidence of the species through the following years. For instance, it has actually been difficult during the last few years to find enough fresh specimens of the San Jose Scale about Ithaca for study in the laboratory and for observance in the field. On the other hand the magnolia scale (*N. cornuparvum*) has apparently been increasing in numbers during recent years. My attention has been called, by correspondents, to excessive infestations of the scale followed by serious injury to its host plants, *Magnolia liliflora* and *Magnolia soulangeana*. The scale has been especially prominent in the city of Ithaca and its outlying districts. Undoubtedly the magnolia shrub is becoming more popular as an ornamental and is therefore more commonly planted. Thus the scale has found its host plentiful and readily accessible.

Again, the natural enemies of the scale may have been scarce during the last few years in which event the insect has probably had little to retard its abnormal increase. I have not seen any evidence of parasites working on this coccid and have not been fortunate enough to rear any parasitic forms from the scale.

HISTORY AND DESCRIPTION.

This magnolia scale existed undescribed until 1902. It had been known previous to that time but had been looked upon and discussed as the species, *Lecanium magnoliarum*. In 1903 it was recognized as a distinct species and described by Thro. as *Lecanium cornuparvum* but was later placed in the genus *Neolecanium* (Fernald 1903 and Sanders 1909).

The female scales, the only ones known to exist, for the males have not been observed, are among the largest and most conspicuous of our scale insects, (Pl. I, Fig. 4).

The females, when grown, become about $\frac{1}{2}$ of an inch in length (8-10 mm.). The body is notably convex and is covered with an abundance of white waxy bloom. When numerous, the host plant looks as though it were covered with masses of white cottony material. When the waxy bloom is removed the body of the scale appears shining brown with numerous honey-comb-like pits and large glands. On removal of the body from the branch, an elliptical scar is left on the bark with four distinct, white lines converging toward the center. These lines mark the position of the spiracular grooves of the insect. The legs are short and stubby and the antennæ have but six, short, indistinct segments.

The overwintering nymphs (Pl. I., Fig. 3) are nearly black with a bluish waxy bloom. They are elliptical in outline and somewhat narrower behind. The median carinæ is high and prominent and slightly lighter in color than the remainder of the body. From 8 to 9 transverse carinæ are present on each side of the median ridge. On each edge of the body are two white spots indicating the entrance to the spiracular grooves. The nymphs vary from .96 to 1.01 mm. in length and from .62 to .76 mm. in width.

The first instar nymph has long, five-segmented antennæ and long slender legs ending in a distinct claw (Pl. I, Fig. 1). The second instar nymph has short, stubby antennæ and legs (Pl. I, Fig. 2). There are three short, stout, spiracular setæ.

FOOD PLANTS AND DISTRIBUTION.

Thro made his original description of the species from specimens taken from *Magnolia* at Trumansburg, New York. Sanders says it occurs on various species of *magnolia* including the deciduous *M. acuminata* of the Northern States. Dietz and Morrison (1916) collected it once in Indiana. Houser (1918) records the scale from several places in Ohio on *Magnolia* and says it has been reported from *Daphne* and *Virginia Creeper*, but these two records in all probability refer to *L. magnoliarum*. We have it here in Ithaca on *M. liliflora* and *M. soulangeana*. Pettit and McDaniel (1920) record it from the cucumber-tree at Orwell, Ohio. Dr. Harold Morrison of the U. S. Bur. Ent. very kindly gave me a list of the States from which the scale has been collected according to the records of the Bureau which run as follows:

STATE	NO. OF RECORDS	STATE	NO. OF RECORDS
Alabama.....	1	Mississippi.....	3
Connecticut.....	1	New York.....	5
Florida.....	2	Ohio.....	10
Georgia.....	1	Pennsylvania.....	33
Indiana.....	1	Virginia.....	1
Kentucky.....	1	South Carolina.....	1
Louisiana.....	7	West Virginia.....	6
Maryland.....	1		

LIFE HISTORY

The insect hibernates as small first stage nymphs on the newer wood. The number of overwintering nymphs is often very great and every available space on the bark is taken up. The nymphs molt rather early in the spring—during the second week in May in 1929. In the first half of June they molt again when each one assumes the elliptical, thickened convex form of the adult. At this time the nymph is of a dark slate, almost purplish color and from $2\frac{1}{4}$ to $2\frac{3}{4}$ mm. in length. In about a week each nymph excretes the white layer of wax over the body and each one soon looks like a small snow-white lump of dough clinging to the bark. The nymphs grow slowly during July but by early August a few females may be found which are mature and have brought forth their first young. For instance, on August 2, during the season of 1929, out of several females examined one had 12 nymphs beneath the body (the females are viviparous). This female had matured early for the other four examined were not yet full grown and had no young. By the latter part of August the majority of the females had matured and had brought forth their young, many of which had already settled on the branches. Some, however, on this late date had only begun to bear young which were still beneath the body of the mother scale. There is thus but one generation a year here at Ithaca.

LITERATURE CITED.

- Thro, Wm. C. Distinctive characteristics of the species of the genus *Lecanium*. Cornell University Agr. Expt. Sta. Bull. 209, p. 216, 1903.
- Fernald, M. E. Catalogue of the Coccidae. Mass. Agr. Expt. Sta. Spec. Bull. 88, p. 176, 1903.
- Sanders, J. C. The identity and synonymy of some of our soft scale insects. In Jour. Ec. Ent., Vol. 2, p. 448, 1909.
- Dietz, Harry F. and Morrison, Harold. In the Coccidae or Scale Insects of Indiana, p. 247, 1916.
- Houser, J. E. The Magnolia Scale. In Bull. 332, Ohio Agri. Expt. Sta., p. 302, 1918.
- Pettit, R. H. and McDaniel, Eugenia. In the Lecania of Michigan. Mich. Agri. Expt. Sta., Tech. Bull. 48, 1920.
- Wilson, C. E. In Scale Insects of Florida. The Quarterly Bulletin of the State Plant Board of Florida, Vol. VII, No. 4 (July), p. 265, 1923.

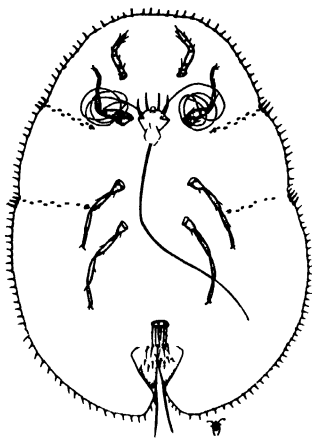


FIG. 1
First stage of magnolia scale

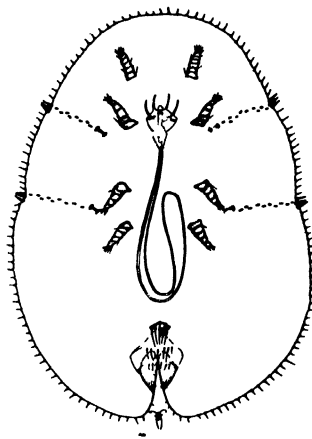


FIG. 2
Second stage of magnolia scale



FIG. 3
Overwintering nymphs of the magnolia
scale.

FIG. 4
Adults of the magnolia scale.
(Natural size.)

INSECTS FROM THE MIOCENE (LATAH) OF WASHINGTON

1. INTRODUCTION, by F. M. CARPENTER
2. HYMENOPTERA AND HEMIPTERA, by T. D. A. COCKERELL
3. ODONATA, by C. H. KENNEDY
4. ISOPTERA, by THOMAS SNYDER
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6. TRICHOPTERA, by F. M. CARPENTER

I. INTRODUCTION.

F. M. CARPENTER,
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Cambridge, Massachusetts.

In 1923 C. O. Fernquist, while collecting fossil plants at an exposure of the Latah formation near Spokane, Washington, found three large beetle elytra in the beds. These were the first remains of insects discovered in that stratum and were described by Professor T. D. A. Cockerell* as representing a single species, *Calosoma fernquisti*. No other fossil insects were obtained in the formation until four years later, when Messrs. T. A. Bonser, C. O. Fernquist and E. E. Alexander collected a large number of plants and 33 insects in the vicinity of Spokane. The following year also a few other insects were secured, making a total of 41 specimens. Professor Edward W. Berry, of Johns Hopkins University, in whose hands this collection was placed, turned the insects over to me for identification; but in order to have the affinities of the fossils determined as accurately as possible, I referred most of them to other entomologists, who prepared descriptions of the species belonging to the groups in which they have been interested. For convenience, these several descriptions are being published under the same general title.

It is always interesting, and frequently important, to compare the flora with the fauna of a formation, whenever the two are sufficiently well known. The plants of the Latah beds

*Proc. U. S. Nat. Mus., 1924, 64, art. 13, p. 4.

were at first described by F. H. Knowlton* in 1923, and they have been more recently and completely revised by Professor Berry†. The latter has recognized 152 species, most of which, of course, are Spermatophytes, although a few Bryophytes, Diatoms, Lycopods, ferns, and conifers are also present. From his study Berry concluded that the Latah flora is an overwhelmingly temperate one, "entirely appropriate to the latitude where it is found and indicative of an ample, well-distributed rain-fall of possibly between 30 and 40 inches annually. It is rather closely paralleled among existing floras by those of such a Middle Atlantic State as Maryland." Berry also substantiated Knowlton's conclusion that the formation is of Upper Miocene age, about the same as the Florissant Shales, Colorado. Knowlton attempted to formulate a picture of the environment of the lake at the time when the plants and insects were entombed: "The area was a broad valley flanked by rolling hills and ridges, some of which rose 1,500 feet or more above the general level, with considerable streams coming down from the north or northwest. Then came the lava flow, which completely dammed the streams, throwing the water back into shallow lakes or ponds The open bodies of water were teeming with microscopic diatomaceous life. Here and there pond weeds floated on the surface, and about the borders were patches of cattails, grasses and sedges."

Of the 41 insects that were collected, nine are sufficiently well-preserved for description and accurate determination of their affinities. The other specimens are so badly distorted or macerated that a classification of them would be very vague at best. The described insects belong to several orders: Hymenoptera, Hemiptera, Odonata, Isoptera, Coleoptera, and Trichoptera. Among the more poorly preserved specimens which are not being described, I fail to recognize any additional orders‡, but there is certainly one other family, the Formicidæ. This group is represented by nine specimens, but only one shows much of the body and, as I have already demonstrated§, it is impossible to determine the generic or even subfamily position of an ant by the venation alone, except in a very few

*U. S. Geol. Surv., Prof. Paper, 1923, 140, pp. 1-81.

†U. S. Geol. Surv., Prof. Paper, 1929, 154-H, pp. 225-265.

‡Two dipterous wings have been sent to A. L. Melander, but descriptions have not yet been received.

§The Fossil Ants of North America. Bull. Mus. Comp. Zool., 1930, 70, No. 1.

cases. The single ant which has the body parts preserved is unfortunately a male, so that it is not possible to determine its affinities either. A photograph of this specimen is reproduced on Plate I, Figure 8.

II. HYMENOPTERA AND HEMIPTERA.

T. D. A. COCKERELL,
University of Colorado.

HYMENOPTERA, FAMILY APIDÆ.

I am greatly indebted to Dr. F. M. Carpenter for sending me for description a very remarkable bee, found by Mr. Fernquist in the now famous Latah beds in the State of Washington. To my astonishment, it is a perfectly typical *Bombus*, and as we have no *Bombus* among the numerous fossil bees from Florissant, it suggests that the Latah formation may be younger than the Florissant Shales. I believe it is the first genuine fossil *Bombus* to be described. The so-called *Bombus* from the Baltic amber belong to other genera. *Bombus grandaevus* Heer from Radoboj is not well enough preserved to be placed generically; it is only about 11 mm. long. *B. conservatus* Weyenbergh, from the Jurassic of Solenhofen, is wholly obscure, and there is no reason for regarding it as a bee. *B. jurinei* Heer, from Baden, is a *Xylocopa*, as I ascertained from a study of the type. *B. abavus* Heer I also regard as a *Xylocopa*. *B. crassipes* Novak, from the Aquitanian of Bohemia, and *B. antiquus* Heyden, from Rott, I cannot at present discuss; it is very desirable that the types should be re-examined.

Bombus proavus sp. nov.

(Plate I, Fig. 7.)

♀ (apparently). Head and thorax black, very robust; no exact details can be made out except that there are many long black hairs on the face, as in *B. americanorum*. Anterior wing very well preserved, 15 mm. long; base to stigma, 8 mm.; length of marginal cell, 4 mm.; combined cubitals, on lower side, 4 mm.; basal nervure going a little basad of nervulus; first intercubitus not at all angulate; first cubital on first discoidal slightly longer than second cubital on same cell; second cubital on margin very little more than third on same cell; lower side of third cubital conspicuously bent at insertion of second recurrent. The wing is hyaline, slightly brownish, the upper part of the marginal cell moderately infuscated.

On comparing the wing with those of various species, it seems to come nearest to the European *B. lapidarius* L. (subg. *Lapidariobombus* Vogt.). This species has the first recurrent near upper end rounded, not angled, basal corner of second cubital cell very acute and first intercubitus not bent near lower end, and in almost every respect closely resembles *B. proavus*.

The following salient characters may be used for purposes of comparison:

1. Shape of third cubital cell. In *B. fervidus* Fb. much shorter in proportion to height; in *B. californicus* Sm. quite different; in *B. argillaceus* Scop. third cubital high and short; *B. terrestris* L. has shorter and higher third cubital; *B. mesomelas* Gerst. has much shorter and higher third cubital. The fossil *Calyptapis* from Florissant has the third cubital very long, so there is some reason to think that its shortening is a progressive or modern feature.

2. Angulation of cubital nervure (in sense of Cresson) at insertion of second recurrent. In *B. proavus* the angulation or bending is strongly marked; so also in *Calyptapis*. It is less strongly bent in *B. kirbyellus* Curtis. In *B. cullumanus* Kirby and *B. rufocinctus* Cress. it is little bent. One would suppose the straight vein to be more primitive, but the angulation is especially marked in the fossils.

3. Relative lengths of the upper sides (on marginal cell) of second and third cubitals. In *B. proavus* the second is very little more than third. In *B. fervidus* Fb. it is as much longer than third; in *B. californicus* Sm. the second is about twice as long as third on marginal; in *B. gerstaeckeri* Mor. the second is much more than third; in *B. pratorum* L. second is much longer than third; in *B. ignitus* Sm. the third is strongly bent near the lower end, making this an aberrant species in respect to venation. In *B. incertus* Mor. the second is conspicuously longer than third on marginal; the same is true of *B. eximius* Sm. I take it that the primitive condition is that of the subequal cells.

4. Angulation of first recurrent near upper end. In *B. proavus* the recurrent is gently rounded, not angulate, which I suppose to be the primitive condition. In *B. lapidarius* L. it is rounded. In the following and many others, it is angulate; *B. impatiens* Cress. (with a little projecting point); *B. kirbyellus*

Curt. (no projecting point); *B. vagans* Sm. (angle very strong); *B. argillaceus* Scop.; *B. terrestris* L.; *B. mesomelas* Gerst.; *B. channicus* Grib; *B. cullumanus* Kirby; *B. rufocinctus* Cress. In *Calyptapis* the first recurrent is gently curved, not bent.

5. Relation of lower end of basal nervure to nervulus. In *B. proavus* it goes a short distance basad of it, as in typical *Bombus* and *Psithyrus*. In the typical members of Robertson's sub-genus *Bombias*, and in *B. rufofasciatus* Sm. it meets the nervulus. In *B. rufocinctus* Cress., which Franklin puts in *Bombias*, it goes basad about as in typical *Bombus*; and in *B. cullumanus* Kirby, it goes far basad. It may be that the meeting of the basal and nervulus is more primitive, as they meet in *Calyptapis*, and in the genera of Prussian amber more or less related to *Bombus*.

In *B. americanorum* Fb. the inner angle of second cubital is not so acute as in the fossil. In *B. occidentalis* Greene I found the outer intercubitus bulging much more in the middle (but in a male, this was not so); *B. dahlbomii* Guer., the most southern species, has the marginal cell more parallel sided (less evidently tapering), and second recurrent more remote from end of third cubital cell.

B. proavus is the first fossil bee in the western Hemisphere elsewhere than at Florissant.

Holotype: Museum of Comparative Zoology, No. 2940 ab.

HEMIPTERA, FAMILY PENTATOMIDÆ

(SUBFAM. TESSARATOMINÆ).

Scudder, in describing the fossil Pentatomidæ from Florissant, noted that the scutellum in the numerous genera is "remarkably triangular and equiangular and destitute of the apical extension common to living types." It appeared reasonable to suppose that since the Miocene time the Pentatomidæ had undergone a forward evolution, resulting in genera which now occupy North America. However, the still older *Pentatomites acourti* (Ckll.), from the Isle of Wight Oligocene, had the scutellum prolonged apically, with a light spot at the tip, such as may often be seen in modern forms. This follows the interpretation of Mr. W. E. China, who examined the type. Furthermore, there is a living group, the Tessaratominae, many genera of which have exactly the kind of scutellum described

and figured by Scudder. It includes the largest known Heteroptera, according to Distant, and is well represented in the Oriental, Ethiopian, and Australian regions. In America, it is now greatly reduced in numbers, with a species of *Pantochlora* in Mexico and Guatemala, and two species of *Piezosternum*, one found at Rio de Janeiro, the other spread from Mexico to the West Indies, Columbia, and Guiana to Brazil. It appears probable, with such evidence as we have, that the Tessaratominae were once the dominant Pentatomidae in America, but have now been almost entirely replaced by other groups: a shifting comparable to that already demonstrated in the Bombyliidae.

From the Latah formation at Spokane we now have a very fine species of the same alliance, but not referable to any of the Florissant genera, though perhaps as near to *Teleoschistus* as to any. There is a rather strong general resemblance to the genus *Origanaus* of Distant from the Naga Hills, India, but that is narrower and has a shorter scutellum.

Latahcoris, gen. nov.

Head (not preserved, but width judged by excavation of pronotum) less than a third as wide as pronotum; pronotum profusely and coarsely punctate, more than twice as wide as long, the lateral margins produced into large obtuse lobes, much as in *Podisus luridus* Fabr.; scutellum triangular, subequilateral, with straight sides and no pronounced apical lobe, its surface coarsely punctate, with an ill-defined impunctate median band (probably it was a pallid line, as in *Amirantea gardineri* Distant); corium broad, unmarked. Appendages not preserved. Longitudinal veins of membrane apparently few.

Genotype: Latahcoris spectatus, new species.

Latahcoris spectatus, sp. nov.

Width of pronotum 12 mm., its length in middle 4.3 mm., but to corners next to eyes, 5 mm.; disc darkened, with three faint pale lines, the outer one gently arched, with the convexity outward. Width of scutellum about 8.5 mm.; length of a side about 8 mm.; length of scutellum, about 6.5 mm.; end of scutellum to end of membrane, about 7 mm.

Holotype: Museum of Comparative Zoology, No. 2941 ab; Brick Yard, Spokane, found in 1927 by E. E. Alexander.

III. ODONATA.

CLARENCE H. KENNEDY,
Ohio State University.

FAMILY LIBELLULIDÆ, SUBFAM. CORDULINÆ.

Miocordulia, gen. nov.

Based upon a right hind wing, probably female. This fossil is well preserved, but was apparently in a worn and fragmentary condition when embedded.

Five antenodals, ten postnodals; five crossveins in R1 area between subnodus and level of stigma, the next crossvein of this row being the single crossvein below the inner end of the stigma which is not developed as a brace vein. Stigma four times as long as wide. Median space free; the arculus arising midway between the first and second antenodals; M1-3 and M4 arising separately on the arculus near its posterior end. (R-M1-3 area between arculus and subnodus collapsed but probably with three crossveins as occur in most of the related genera.) Two crossveins below subnodus connecting it with the bridge vein, the next or third crossvein of this series being the diagonal crossing of Rs; thirteen simple crossveins between M2 and Rs beyond the Rs crossvein. An Rs supplementary sector about ten cells long. Eighteen crossveins between M3 and M4; a short supplementary sector of four large cells being M4. Three rows of cells between M4 and Cu1. This three-rowed area extends out from the triangle a distance of six cells, ending at the level of the fork of M1-2 and the bridge vein.

Subtriangle present; triangle crossed, its inner angle arising at the lower end of the arculus; Cu-A crossvein midway between triangle and base of wing; fourteen cells between Cu1 and Cu2, cell No. 7 being at apex of the anal loop. (Anal loop with only the base, upper tier of cells and apex of loop preserved.) Nine cells in the upper tier of the loop; three cells across the base of the loop, the third or extra cell being triangular and separating the upper and lower tiers of the loop. On vein A basad of the loop arise three veins which extend into the anal field. The first of these from the base of the wing is heaviest and curves after the fashion of the vein bounding the outer side of the anal membrane, which it probably is though no remains of the membrane are evident. Thus between the inner angle of the subtriangle and the base of the wing are five cells behind vein A*. (Three rows of five to six sided cells in the anal area behind the anal loop?)

The courses of the main wing veins are as follows: M1a well developed, arising under outer end of stigma and diverging from M1;

*The area behind A between the base of the wing and the anal loop is identical with that in the female *Epicordulia*. In the male this area is more condensed.

M2 and Rs diverging in first third of course then converging to the level of the stigma, then slightly diverging to margin of wing. M3 and M4 slightly converging to level of subnodus, then slightly diverging to outer fourth after which they converge rapidly to the margin of the wing. A mere suggestion of sinuosity in the course of M3.

Genotype: Miocordulia latipennis new species.

***Miocordulia latipennis*, sp. nov.**

(Figs. 1, 2; Plate I, Fig. 6.)

Approximately 35 mm. long and 11 mm. broad at the level of the nodus; base to nodus, 14 mm.; stigma, 4 mm. long, by 1 mm. broad. Other characters as given in the generic description.

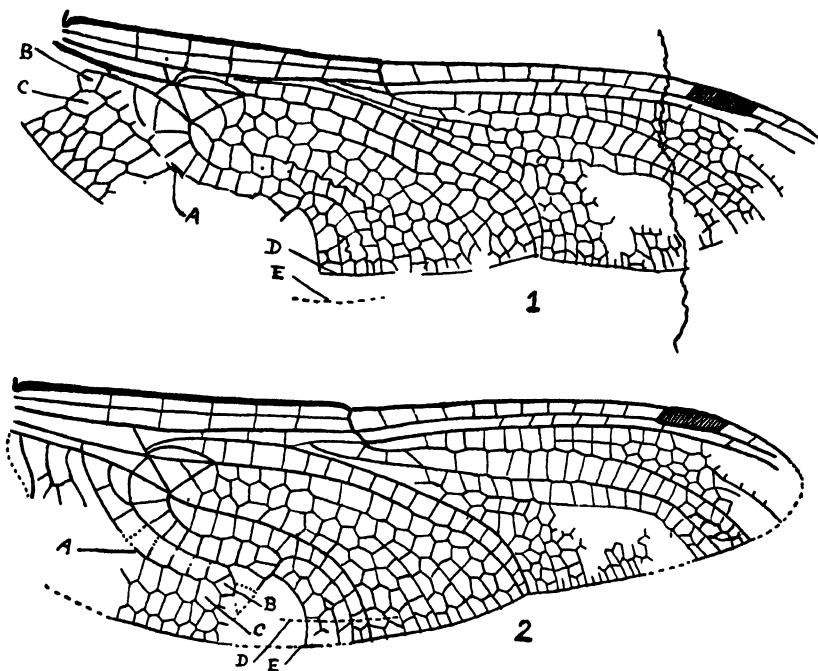


Fig. 1. *Miocordulia latipennis* Kennedy. Drawing of the fossil wing as it appears on the obverse print. The area from A to C is out of place and reversed lengthwise.

Fig. 2. Restoration of the wing of *Miocordulia latipennis* Kennedy.

Holotype: Museum of Comparative Zoology, No. 2942 ab. Found near Spokane, Washington, by Mr. C. O. Fernquist, 1927.

Discussion: Fig. 1 is a drawing of the fossil itself. The tip of the wing, the area below the supplementary sector of Rs and the area below the anal loop are missing.

A curious anal area at the extreme base of the wing is present, an anal area like nothing else in the Cordulines as it extends too far basad by a distance of at least two cells. Just casually it appears to connect up with the anal loop and vein A. This is as it appears on the obverse. From a study of the reverse suspicions arose that this connection was not so certain. Apparently branches of vein A passed under this anal area. The author took the liberty of chipping enough off of the reverse to expose fully these basal veins as shown in Fig. 2. This showed at once that this anal area was a loose fragment entirely out of position. How then to interpret the anal fragment?

An examination of Fig. 1 shows that nowhere—unless at the right upper corner of the anal fragment is it absolutely continuous with the main fossil print. Each of the other (apparently connecting) crossveins is broken. As located in Fig. 1 the anal area does not fit any genus of living Cordulinae. The writer believes that it is a fragment from beneath the outer end of the anal loop which has floated up and over, towards the base of the wing, thus lying under surface up with its ends reversed. Its distal end then lies at the extreme base of the wing and its basal end under the base of the anal loop. If this is true then it should be reversed and its present basal end become its apical end at the anal loop as shown in Fig. 2. The connection (A) in Fig. 1 appears confused in the fossil as though there were a doubling up of crossveins. This is probably the anchor or axis about which the fragment rotated and was probably attached to the third cell of the upper tier of the anal loop.

The whole wing is obviously distorted in minor ways. Fig. 1 shows the many wavy and crumpled crossveins in the disc of the wing. In the restoration, Fig. 2, this area has been widened, the distance from D to E. The fragment on the other hand appears to have been stretched as all of its crossveins are tense and straight. Moreover, its true distal end is too wide to fit within any contour under the outer end of the anal loop. To make the fragment fit under the apex of the anal loop the outer end of the fragment was narrowed to bring its hind edge within the contour of the hind edge of the main

fossil as drawn in the restoration, Figs. 2, E. When this was done every detail of the fragment fitted logically. The cell B, Figs. 1 and 2, is in the turn of the anal loop and the eight-sided cell C falls into its natural place. The vein from A to B becomes natural in that its A-end is heavy and straighter than the B-end which becomes more zig-zag. Thus it forms, with the curve around cell C, the vein bounding the under side of the anal loop. This solution places the vein A-B in a logical position and also takes care of the puzzling cell B which is perfect and complete in the fossil and because of its shape can be fitted nowhere else as precisely.

This gives a wing which has characters of *Somatochlora* and of *Epicordulia* yet differs from either in the three rows of cells extending outward from the triangle and in the greater width of the base. It differs from *Somatochlora* in having three rows of cells behind the anal loop and from *Epicordulia* in having a subtriangle. It is also close to *Epitheca* which has a subtriangle, four rows of cells behind the anal loop and almost three rows of cells beyond the triangle. Thus this fossil has characters of the European *Epitheca*, the American *Epicordulia* and the Holarctic *Somatochlora*. Apparently it is closest to the European *Epitheca* though the shapes of the cells of the anal area of that genus are less regular than those of *Somatochlora* and *Miocordulia*. As *Epicordulia* with a widely spread eastern species, *princeps*, and a Florida species, *regina*, stands apart as a genus from our other American Cordulinæ this genus, *Miocordulia*, may be a link connecting it back to the Palaearctic fauna.

Epicordulia regina is one of several species of Odonata that are rather definitely limited to Florida, a group of species which the writer has felt may date back to the old Miocene island of Florida off the coast of our present Georgia. If *regina* arose by isolation in the Miocene island of Florida, this gives us a slight check on the time of the entry of the *Miocordulia* and *Epicordulia* stock into America from the Orient.

IV. ISOPTERA.

THOS. E. SNYDER,

Bureau of Entomology, U. S. Dept. of Agriculture.

FAMILY RHINOTERMITIDÆ.

The fossil termite which was sent to me for identification proves to be a species of *Stylotermes* new to science. The genus *Stylotermes*, in the family Rhinotermitidæ, was established by Karin and Nils Holmgren in 1917, (Mem. Dept. Agric. India, vol. 5, No. 3, p. 141-2), with an East Indian species as genotype. This termite from South India is the only *living* representative of this genus. However, at least one *fossil* species occurs in Baltic Sea amber. *Stylotermes* is of particular interest since it exhibits characters which are connecting links between the lower termites in the family Kalotermitidæ and those in the intermediate family Rhinotermitidæ.

Stylotermes washingtonensis n. sp.

(Plate I, Fig. 5.)

Wing. Forewing (?). Subcostal vein joined to the costal margin by numerous vertical short veinlets. Wing membrane strongly reticulated with accessory veins arising vertically from the nervures. Median vein free from stump, closer to cubitus than to subcosta with numerous, (as many as 20), closely placed, branching branchlets to posterior margin of the wing. All veins are prominent and thickened. Wing scale or stump not present.

Length of wing: 11.5 mm.

Width of wing at widest portion: 3.0 mm.

Holotype: Museum of Comparative Zoology, No. 2943 ab. Collected by C. O. Fernquist, near Spokane, Washington.

V. COLEOPTERA.

H. F. WICKHAM,
University of Iowa.

Two specimens are in such fragmentary or imperfect preservation as to give no particular clue to their position, but the remainder fall into two species which appear to be readily placed. Descriptions of the latter follow.

FAMILY CARABIDÆ.

***Pterostichus fernquisti* n. sp.**

(Plate I, Fig. 1.)

Represented by three elytra, one in obverse, the other two in reverse. Form only moderately elongate, striae fine, not very deep, minutely punctured. Scutellar stria of moderate length, joining the sutural. Interspaces very little convex. Marginal interruption strong. Ocellate submarginal punctures strong, rounded, close together behind the humerus, then widely spaced, becoming deeper and closer again on about the apical half.

Length, 11 mm.; greatest width, 3.50 mm.; length of scutellar stria about 1.75 mm.

This seems to be a genuine *Pterostichus* of the same general type as the numerous recent species inhabiting the Pacific coast of North America and extending into the Rocky Mountains. Perhaps it is most reminiscent of *P. gracilior*.

Holotype: Museum of Comparative Zoology, No. 2944 ab; paratypes, Nos. 2945, 2946. Holotype, an obverse. Paratypes, two specimens in reverse, labelled Deep Creek Canyon, C. O. Fernquist, 1928.

FAMILY DYTISCIDÆ

***Dytiscus latahensis* n. sp.**

(Plate I, Fig. 3.)

Represented by somewhat less than the distal half of a left elytron which, by its tapered form, evidently belonged to a species not decidedly broader behind. The surface shows the posterior ends of five impunctured sulci and the barely visible tips of two others, all shallow for the short distance over which they are impressed. Posterior to these, the elytron is finely punctured, becoming more heavily so apically, but none of this punctuation is so pronounced as in our recent *D. fasciventris*. The sutural stria is fine visibly punctate and traceable nearly to the apex. The outer elytral edge is marked by a light submarginal stripe, giving off, near its tip, a broader arcuate curved band with the convex side anterior.

Length of fragment, along suture, 10.8 mm.; width 8.70 mm.

Not unlike the figure of *D. lavateri* Heer, from the Oeningen beds, but that does not exhibit such a long sutural stria. This stria is also less plainly marked apically in all of the recent species to which I have access, the nearest approach to it being in some specimens of *D. harrisi*. The markings described appear to be a genuine elytral pattern and not due to abrasion. From the presence of sulcations it is presumed that the specimen was a female.

Holotype: Museum of Comparative Zoology, No. 2947. Marked E. E. Alexander, Spokane, Washington, 1927.

VI. TRICHOPTERA.

F. M. CARPENTER,
Harvard University.

Six specimens of caddis-flies as well as caddis cases* are present in the collection of Latah fossils. Considering their aquatic development, it is not surprising that these insects should be represented, but the number of species is much larger than one would expect in a collection of this size. Fifteen per cent of all the specimens belong here. The magnitude of this proportion takes on some significance when we compare the trichopterous fauna of the Latah beds with that of the Florissant Shales. Scudder's examination of about twenty thousand Florissant insects showed that less than 4% of the species were Trichoptera, which means that the caddis-flies seem to be about four times as numerous at the Latah beds as at those of Florissant. It is also interesting to note that of the six Latah specimens, five are Limnephilids (representing five species) and the other is a *Phryganea*. In marked contrast to this, the specimens in the Florissant Shales comprise 95% Hydropsychids, 4% Phryganeids, and 1% Limnephilids. In other words, the family Hydropsychidae, which is far and away the most abundant at Florissant, is absent in the Latah collection, while the family Limnephilidae, of which only two species have been found in some twenty thousand Florissant insects, is represented by five species out of a total of 41 fossils from the Washington deposit. It must be admitted, of course, that these statements lose some of their force in view of the small number of Latah insects known, but I nevertheless believe that they have considerable significance. The Hydropsychidae, which are so abundant at Florissant, breed only in rapid streams or active waters of lakes. The Phryganeidae and very nearly all the Limnephilidae, on the other hand, develop in standing water which usually contains much plant life, or in quiet streams. This would seem to verify Knowlton's conclusion, quoted above, that the lake which deposited the beds was shallow and contained a diverse flora.

*Berry, Edward W. A Caddis Case of Leaf Pieces from the Miocene of Washington. Wash. Acad. Sci. Jour., Vol. 18, No. 3, pp. 60-61, Fig. 1, (1928).

FAMILY PHRYGANEIDÆ.

Phryganea spokaneensis sp. nov.

(Fig. 3.)

Described from a well-preserved fore wing, complete except for the very apical margin. Length, 19 mm.; width, 5 mm.; anterior margin slightly convex, apex regularly rounded, posterior margin gently curved; subcostal space broad, much as in the recent *Ph. varia*; Sc quite straight; R1 close to Sc, straight, with a prominent pterostigmal hump; discoidal cell slender; Cu diverging from M well beyond the origin of Rs; the common stem Cu+M joins R at the base of the wing; M3+4 unbranched; 1A and 2A close together at base; 3A looped to 2A distally, and 4A looped to 3A, as characteristic of the genus.

Holotype: Museum of Comparative Zoology, No. 2948.

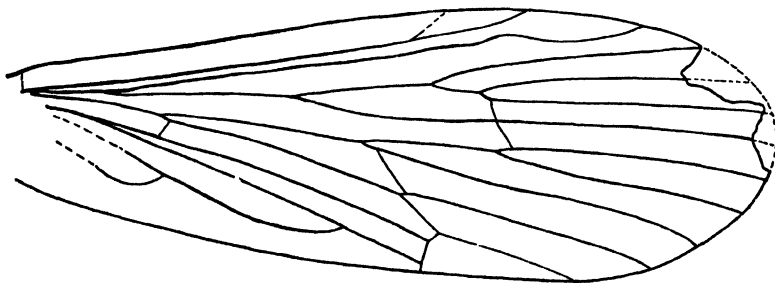


Fig. 3. *Phryganea spokaneensis* Carpenter. Drawing of fore wing.

The generic characteristics of this fossil are so obvious that I do not hesitate to place the species in the genus *Phryganea*. The looping of A3 and A4 distally; the shape of the discoidal cell, with a large part of R2 forming a portion of the anterior wall; and the shape of the thyrid cell, with its oblique distal wall, are characters not found combined in any other genus. *Phryganea* is represented by nearly 30 extant species, widely distributed in Europe, Asia, North America, and portions of South America.

FAMILY LIMNEPHILIDÆ.

Miopsyche, gen. nov.

Allied to *Limnephilus*. Anterior margin convex; apical border flattened, as in *Limnephilus*; posterior margin straight or slightly concaved; pterostigma distinct; discoidal cell long; anal veins as in *Limnephilus*.

Genotype: *Miopsyche alexanderi*, sp. nov.

The genera of Limnephilidæ, of which there are about fifty described, present a diversified wing structure, so diverse, in fact, that it is impossible to determine from wing characters alone the exact position of a species. Rather than attempt to assign these two Latah Limnephilids to a recent genus, I establish a new one for their reception until other specimens are found showing sufficient body characters to enable us to determine more accurately the generic affinities.

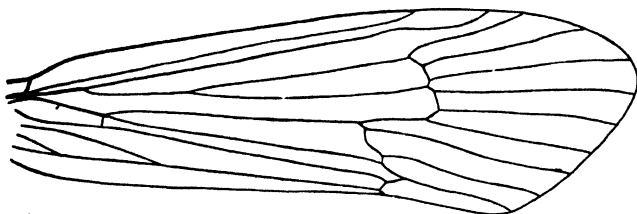


Fig. 4. *Miopsyche alexanderi* Carpenter. Drawing of fore wing.

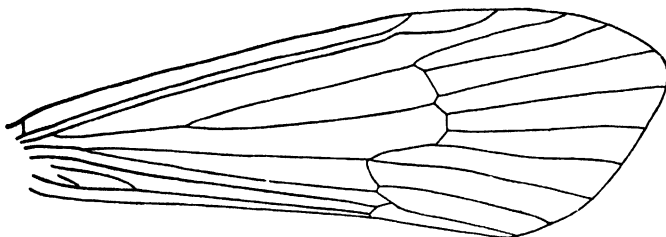


Fig. 5. *Miopsyche martynovi* Carpenter. Drawing of fore wing.

***Miopsyche alexanderi*, sp. nov.**

(Fig. 4.)

Described from a complete fore wing. Length, 20.0 mm.; width, 6.0 mm. Subcostal space broad, much narrowed basally. R1 straight up to the pterostigmal hump; basal walls of first and second apical cells equal; subradial cell only slightly broader apically than basally; basal walls of sixth and eighth apical cells equal; that of the seventh cell much longer, and gently sigmoidal.

Holotype: Museum of Comparative Zoology, No. 2949. Collected at Spokane, by E. E. Alexander, for whom the species is named.

Miopsyche martynovi, sp. nov.

(Fig. 5.)

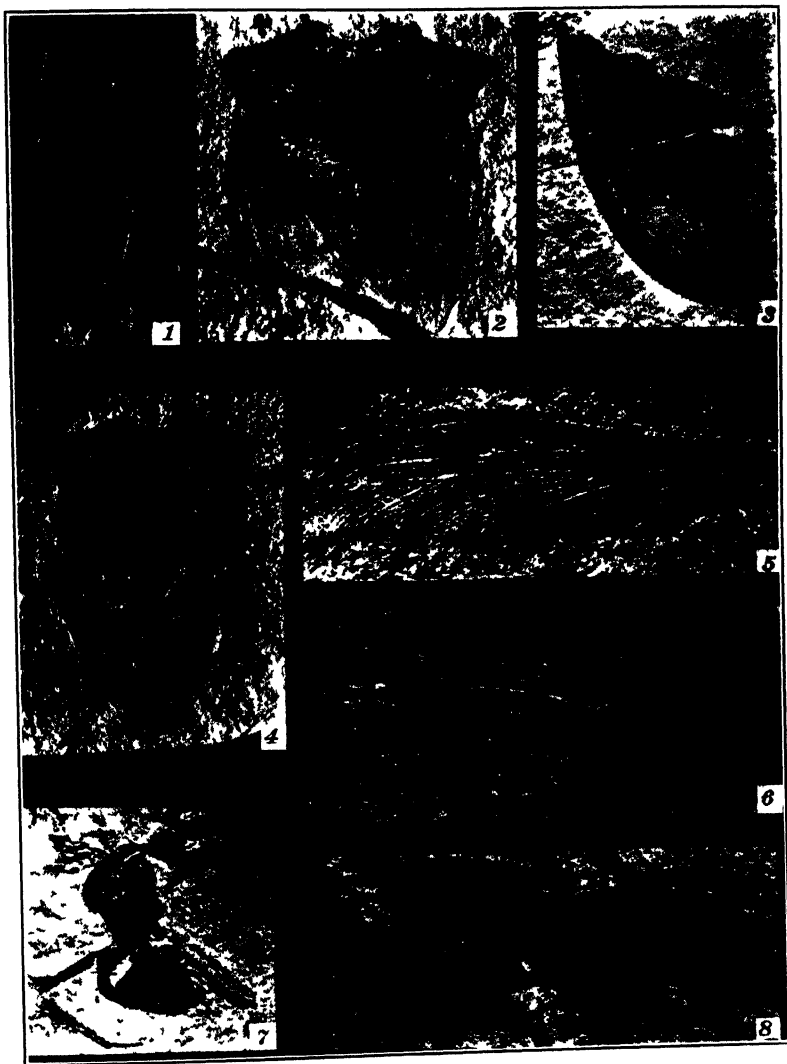
Described from a complete fore wing. Length, 17.0 mm.; width, 5.0 mm. Anterior margin more convex than in preceding species, apical border more rounded, and wing broader apically. Subcostal space much narrower than in *alexanderi*; basal wall of first apical cell about $\frac{1}{2}$ as long as that of the second; discoidal cell narrower than that of foregoing species; subradial cell much broader distally than basally; sixth apical cell pointed basally; basal wall of seventh apical cell about three times as long as that of cell eight.

Holotype: Museum of Comparative Zoology, No. 2950. This species is named for Dr. A. V. Martynov, in recognition of his investigations on Trichoptera and fossil insects.

The other caddis-fly wings in the collection are incomplete, only the distal halves being preserved. It is obvious from their shapes and preserved portions that they represent distinct species, all of the family Limnephilidae; but because of the absence of the basal parts of the wings, we find it impossible to determine their generic affinities. In view of the abundance of trichopterous wings in the Latah beds, it is very likely indeed that complete specimens of these species will soon be found. Meanwhile, rather than add to the already too long list of fossils with "uncertain" affinities, we shall wait for further material before describing and naming the species.

EXPLANATION OF PLATE.

- Fig. 1. *Pterostichus fernquisti* Wickham, holotype, ($\times 4$).
Fig. 2. *Latahcoris spectatus* Cockerell, holotype reverse, ($\times 3$).
Fig. 3. *Dytiscus latahensis* Wickham, holotype ($\times 4$).
Fig. 4. *Latahcoris spectatus* Cockerell, holotype obverse, ($\times 2.5$).
Fig. 5. *Stylotermes washingtonensis* Snyder, holotype ($\times 5$).
Fig. 6. *Miocordulia latipennis* Kennedy, holotype reverse, ($\times 1.8$).
Fig. 7. Male ant, ($\times 4$).
Fig. 8. *Bombus proavus* Cockerell, holotype ($\times 2$).



ECOLOGY OF TOXOPTERA GRAMINUM, ESPECIALLY AS TO FACTORS AFFECTING IMPORTANCE IN THE NORTHERN UNITED STATES.*

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INTRODUCTION.

The unexpected and severe outbreak of *Toxoptera graminum* Rondani, a grain aphid often called the "green bug," in Minnesota in 1926, has led to an investigation of factors governing such outbreaks. Such a study seems desirable because of the light it may throw on its capacity for injury, especially in the north. It is also of interest because of the need for more information on the life economy of the aphid group in general.

Credit is due Dr. R. N. Chapman, Dr. W. C. Cook and Prof. A. G. Ruggles, under whom the work was carried out; and to other members of the Minnesota faculty, and graduate students, for many helpful suggestions. Records of the United States Weather Bureau have been freely used, Mr. Pursell of the Minneapolis office helping to make them available.

Since the original description in 1852, from Italy (Rondani 1852) the species has periodically been injurious and has attracted considerable attention, as evidenced by numerous articles. A large part of this literature is summed up by Webster and Phillips (1912). Some articles have appeared since, the more important from the present standpoint being by Headlee (1914), Moore (1914), Phillips (1915), Kelly (1917), Luginbill and Beyer (1918), Tucker (1918), Walton (1921), Garman (1926), Sanborn, Brown, and Bieberdorf (1926), Ruggles and Wadley (1927), and Wadley (1929). The recorded distribution includes large parts of North America, Europe, Asia and Africa, with the greatest injury in the southern United States, Italy, Hungary, Southern Russia and South Africa. The literature shows that the species is quite similar in its life history to other important aphids, except that the winter egg plays a less important part than with some others. Relations to enemies are like those of other aphids. With unimportant exceptions, only grasses have been recorded as hosts, and wheat and oats as most injured. The species seems to have an unusual power of inflicting injury.

Besides Webster and Phillips' comprehensive bulletin, several papers have dealt especially with ecology. Glenn (1909) worked on relation to climate, Headlee (1914) on effects of moisture and temperature, and Moore (1914), Tucker (1918) and Luginbill and Beyer (1918) discussed ecological problems. In the present work the effort has been to carry on a careful

study of the ecology of the species, and to apply known facts to problems of distribution. Previous contributions will be more fully discussed in treating the subjects to which they apply.

PART I.

A STUDY OF THE ECOLOGY OF TOXOPTERA GRAMINUM.

LIFE HISTORY IN GENERAL.

The life cycle agrees in many respects with that typical of the Aphididæ. Winged and wingless females reproducing parthenogenetically and viviparously are the forms usually found. The wingless females occur most abundantly and constantly. Winged females produce progeny nearly all wingless, while wingless parents produce both winged and wingless progeny. Under certain conditions, typically in the fall, the parthenogenetic families may include some winged males, and wingless non-parthenogenetic oviparous females. The eggs produced by the latter after mating may pass the winter, and hatch in the spring, producing wingless parthenogenetic females. These types of adults may be termed biological forms. Males, oviparous females, and eggs, appear to be rare in the field in Minnesota; and are probably not of much significance in the economic importance of the species. The males and oviparous females are usually referred to as "the sexes" or "sexual forms" to distinguish them from the parthenogenetically reproducing winged or wingless females, and a variety of other terms for them occur in the literature. The writer prefers the term zygogenetic, used by Wilson (1915) to distinguish them from the parthenogenetic forms, although usage makes the simpler term convenient.

Detailed life history studies are reported by several workers, especially Washburn (1908, A, B, C), Hunter (1909), and Webster and Phillips (1912). They include figures, descriptions and measurements. Washburn's work is of special interest because it was done in Minnesota, and includes the first description of males and oviparous females.

The species may be distinguished from other grain aphids by the once-branched media in the winged form; also by the pea-green color with darker green dorsal line, the black eyes, and the green cornicles with dark tips. The wingless parthenogenetic female is typically about 1.8 mm. in length and .8 to .9 mm. in greatest width. The winged female is somewhat smaller, the oviparous female a little larger, and the male smallest of all. Unfavorable conditions have produced smaller adults.

The nymphs pass through four instars in development, the time required being about a week with summer temperature, but varying widely. Advanced embryos occur in late fourth instar nymphs. The wingless parthenogenetic females may begin reproduction within a few hours after the last molt; winged females usually do not reproduce

until 24 to 48 hours after the molt. In Table I are assembled rearing records, secured in chimney cages on oat plants, in the greenhouse from April 1 to September 30, and in the outdoor insectary in June, July and August. In these cases food, temperature and day-length were all fairly favorable.

TABLE I.
ADULT LIFE AND REPRODUCTION UNDER FAVORABLE CONDITIONS.

	WINGLESS PARENT			WINGED PARENT		
	No.Cases	Average	Range	No.Cases	Average	Range
Total number young..	19	63.1	2 to 83*	4	39.5	14 to 51
Days of reproductive period.....	19	22.7	1 to 37	4	16.8	6 to 23
Days post-reproductive life.....	19	2.7	0 to 9	4	5.0	1 to 10

*Only one case less than 40.

TABLE II.
OUTDOOR REARING RECORDS BY MONTHS.

Month	Approximate No. Generations Reared	Young per Day; Wingless Parents Early in Reproduction*	Average Temperature F.
1926.			
August.....	3½	3.7	70.5
September.....	2 +	2.5	57.5
October.....	1 +	0.8	48.5
1927.			
April.....	½	0.6	48.0
May.....	1½	1.0	55.0
June.....	3	2.3	64.0
July.....	4	3.0	71.0
August.....	3	2.6	67.5
September.....	2 +	...	64.0
October.....	1 +	1.4	53.5

*First 10 days.

Reproduction rate early in adult life is of more importance in rapid increase than the rate throughout life. An average of 3.5 young per day for the first 10 days of reproduction, was secured from 31 wingless females, kept under rather favorable conditions, in insectary and greenhouse. Four young per day seems to be about the maximum rate which can be sustained several days by young wingless adults, although as many as 10 have been produced in individual days. Winged adults are less prolific.

Oviparous females produced an average of about three eggs each and a maximum of seven in this study; usually not more than one in a day. They did not oviposit sooner than 3 to 5 days after maturity and not later than 15 days, though some lived nearly a month as adults. Eggs failed to darken normally when males were not kept with the females, and in some cases when they were. Webster and Phillips (1912) discuss the embryology of these eggs, and note that they will not hatch unless they have been subjected to freezing weather.

EFFECTS OF TEMPERATURE.

The effects of temperature include effects of variations within the range of possible development, and of extreme temperatures.

The effects of temperature within the range of development may be observed in rate of development, rate of reproduction, total length of life and number of young, and appearance of biological forms. Population increase is a resultant of some of these factors.

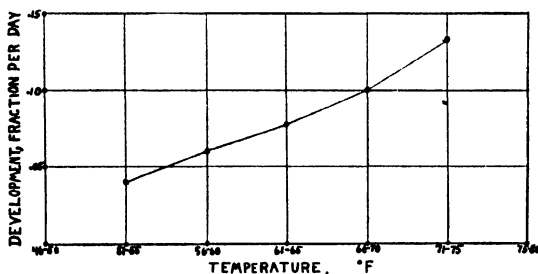


Fig. 1. Temperature and rate of development, outdoor results.
By five-degree groups.

EFFECTS ON LIFE, REPRODUCTION AND DEVELOPMENT.

Rearing records in the outdoor insectary are summarized in Table II, and data on development are graphically presented in Fig. 1. Rearing was done in chimney cages on oats, using wingless parents except in one case (June 21). A maximum and minimum thermometer set was used except in August and September, 1926, when a Tycos recording thermometer was used, and in May and June, 1927, when St. Paul Weather Bureau records were used. Insectary temperatures were near those recorded by the Weather Bureau throughout the work.

In both 1926 and 1927, slow development took place in October, but none in November. The aphids perished from cold during the latter month. In 1927, March was too cold for reproduction, only 5 days averaging above 44° F.; a parent was caged outdoors on April 4, and first reproduced April 11.

Summer temperatures in Minnesota were usually a little too low for maximum growth and reproduction. Rearing at outdoor temperatures has been recorded by Webster and Phillips (1912) for Indiana and

northern Texas; by Tucker (1918) for northern Texas; and by Luginbill and Beyer (1918) for South Carolina. In Indiana, in summer months averaging about 75° F., reproduction appears to be as rapid as in late spring or early fall, and development more rapid. In Texas and South Carolina, where summer months average 80° F. or higher, reproduction is depressed by the heat, but development is nearly as rapid as in May and September.

TABLE III.
DATA ON DEVELOPMENT.

	Temperature ° C.	° F.	No. Reared	Average Days to Develop	Range, Days
Wingless	7	44.6	4	33.2 ± 1.078	30 to 36
	10	50.0	44	31.8 ± .257	26 to 37
	12	53.6	21	20.8 ± .307	19 to 27
	14	57.2	49	17.9 ± .150	14 to 22
	17½	63.5	53	11.6 ± .091	9 to 14
	20	68.0	51	8.4 ± .072	7 to 10
	22-23	72.5	61	7.2 ± .059	6 to 9
	26	78.8	31	6.5 ± .082	5 to 7
	30	86.0	71	5.9 ± .061	5 to 8
	32	89.6	17	6.9 ± .306	6 to 14
	33	91.4	2	7.0	No range
Winged	10	50.0	4	34.5 ± 1.118	31 to 39
	12	53.6	16	26.1 ± .313	24 to 31
	14	57.2	12	19.4 ± .232	17 to 21
	17½	63.5	7	13.0	None
	20	68.0	11	9.0 ± .091	8 to 10
	22-23	72.5	16	7.6 ± .106	7 to 9
	26	78.8	19	6.4 ± .073	6 to 7
	30	86.0	12	5.5 ± .102	5 to 6
	32	89.6	6	6.0 ± .269	5 to 7
Males	17	62.6	5	11.9	11 to 14
	22	71.6	4	7.7	7 to 9
Oviparous Females	17	62.6	2	12.5	12 to 13
	22	71.6	2	7.5	7 to 8

Laboratory results are more exact and satisfactory in a study of temperature effects. Headlee (1914) records results with constant temperatures of 50°, 60°, 70°, 80°, and 90° F., finding reproduction and development most rapid at 80°. In the present work rearing was done in chambers regulated by thermostats controlling heating lights; those below room temperatures were cooled by ammonia-chilled brine in the back walls. Temperatures were practically constant. Constant light was supplied by 100-watt nitrogen "daylight" bulbs shining through the glass ceilings and concentrated by shades; small electric fans kept the air in motion. Lamp chimney pot cages containing oats were used. Humidity was not measured; other experiments

showed that *Toxoptera* thrives in a wide range of humidity. The plants did not hold up as well as in the greenhouse, probably because of the smaller amount of light. However, rearing was carried on without difficulty. Data are believed to show the effect of temperature quite accurately, and results in the different chambers are strictly comparable with each other.

TABLE IV.
REPRODUCTION AND ADULT LIFE.

Temperature		No. Adults Used	AVERAGE YOUNG PER DAY		Average Total No. Young	Mean Repro-duction Period, Days	Mean Adult Life, Days	
			Early in Period	Whole Period				
° C.	° F.	WINGLESS ADULTS						
7	44.6	2	0.41	0.41	7.5	18.5	22.0	
12	53.6	6	1.0	0.88	25.0	28.5	31.2	
17-17½	63.0	8	2.19	1.84	37.1	20.1	20.8	
20	68.0	4	3.06	2.28	52.5	23.0	24.0	
22-23	72.5	8	4.32	3.71	52.1	14.0	14.3	
*26-27	79.7	6	4.09	3.58	69.3	19.3	20.3	
30	86.0	4	3.74	2.77	36.8	13.3	14.0	
32	89.6	7	1.72	1.72	7.9	4.6	6.9	
34-35	94.1	3	1.75	1.75	4.7	2.7	6.0	
		WINGED ADULTS						
7	44.6	2	0.37	0.37	10.0	27.0	41.0	
12	53.6	2	0.66	0.66	10.5	16.0	21.5	
17½	63.5	3	1.48	1.28	19.7	15.3	17.7	
†20 (all long lived)	68.0	6	2.03	1.72	19.5	11.3	13.2	
	68.0	3	2.29	1.78	35.0	19.7	21.7	
23	73.4	3	2.48	2.52	43.0	17.3	18.3	
26	78.8	3	2.25	2.36	34.7	14.7	17.0	
30	86.0	3	2.0	1.73	17.3	10.0	13.3	
32	89.6	4	1.8	1.8	8.5	4.8	9.8	
34-35	94.1	2	1.0	1.0	4.0	4.0	8.0	

*At 26-27°C., 3 wingless adults escaped before completing their reproduction period.

†At 20°, 3 alate adults died soon after maturity for some unknown reason; hence 3 others were used and averaged with the first 3.

In the work on development, several parents from the greenhouse were caged together and allowed to produce a number of young of the same age, then removed. The cage was then put in the desired temperature chamber, the young reared, and removed each day, as they matured. Periods for individual aphids were recorded in days, without fractions. A majority of the nymphs started usually matured; however, at 7° and 32° C., considerably less than half were reared successfully.

The probable error of the differences between times of development at any two temperatures, is the square root of the sum of the squares of their probable errors. In most cases this error is very small in proportion to the difference, indicating that the difference is significant. Exceptions are found at the extremes of the series, where only a few were reared.

In work on adult life and reproduction, large nymphs from the greenhouse were caged at constant temperatures until death, progeny being counted and removed daily. The daily average number of young early in adult life has been computed, as before, as a good index to rapidity of increase. The period used here is the time previous to maturity of oldest offspring at the given temperature. At low and high temperatures this is no shorter than the entire reproductive period.

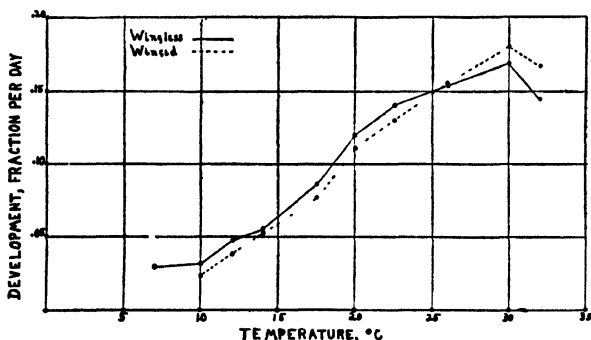


Fig. 2. Constant temperature and development, laboratory results.

In other experiments a few incomplete figures were secured. At 14° C., 5 wingless aphids produced 17 young in 2 days, early in adult life; at 10° C., 4 young wingless adults produced 11 young in 3 days; these records show the same trend as those above.

At 5° C., 10 vigorous wingless adults produced 2 young, and 35 nymphs cast 4 molts, in 2 days; at 4° C. the same aphids cast no molts and produced 1 young in 2 days; no sign of development was seen in 2 days at 3°. In view of the difficulty of rearing at 7° C., it seems doubtful that complete development could take place at 4° and 5°.

At 30° depressing effects of high temperature are seen; at 32° there is considerable decrease in life length, total young and reproductive rate, and some in developmental rate, which becomes variable. Adults maturing are smaller than at lower temperatures; 7 typical ones averaged 1.31 mm. in length, .53 mm. in greatest width. Two nymphs were reared at 33° C. Nymphs failed to mature at 34 to 35° C., though some lived 7 days. At 34 to 35° C., adults produced a number of young the first day in the cabinet, and a few afterwards; at 37° and 38°, they produced a few young the first day, none afterward; at 40°, none at all. It has been noted several times that adults moved from moderate temperatures to 32° to 35° C. reproduce rapidly the first

16 to 24 hours and only slowly afterwards; this is similar to effects found by Cook (1927) in cutworms.

One experiment in alternating temperatures, 22° and 12°, was carried out; periods of 8 and 16 hours each were used, so arranged that an equal time was spent at each temperature for the period. Wingless young developed in 9 to 11 days, 14 averaging 10.1 days; 5 wingless adults averaged 2.48 young per day for 9 days. It will be seen that these rates are higher than would have been expected from the average, 17°, but not much higher than would be expected from a combination of two equal periods at 12° and 22°.

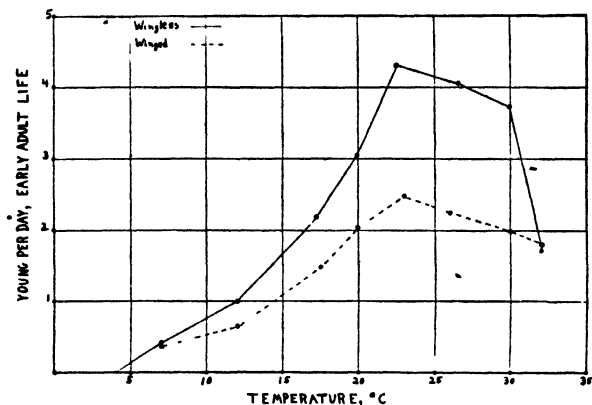


Fig. 3. Constant temperature and reproduction, laboratory results.

Figures 2 and 3 express graphically data on development, and on reproduction early in adult life, at constant temperatures. It is seen that development follows a fairly straight line within the range of moderate temperatures; but reproduction rate follows a somewhat curved line, the highest point being at 22-23° C. The high reproduction rate at this temperature has been observed in two sets of experiments. Results suggest that the winged form is adapted to slightly higher temperatures than the wingless. A majority of the nymphs died at 7° and 32°; those maturing may have been selected groups, and results at these extremes may not be as reliable as at the other temperatures in plotting the temperature-development curve.

Length of adult life and reproduction period did not vary significantly with the parents used through the medium temperature zone; except that with wingless adults it averaged lower with the exceptionally rapid reproduction at 22° to 23° C. This latter fact has been observed in two experiments. At 30° life-length was significantly decreased; at higher temperatures it was much shortened. Below 17° C. adult life was somewhat lengthened. Adding time of nymphal development and adult life as recorded, it will be seen that total life is from 3 to 6 weeks at moderate temperatures, and may approach or exceed 2 months in cooler seasons.

Total number of young per adult is greatest at 20° to 27°, and is reduced at higher and lower temperatures. At higher temperatures life is shortened and reproductive rate reduced. At lower temperatures the reproductive period is lengthened, but not in proportion to reduction of reproduction rate; hence total number of young must be smaller. The out-door rearing also shows this; in April, May and October wingless parents averaged 27.8 days reproduction and 27 total young; while from June 1 to September 15 averages were 24.1 days and 60.3 young, respectively.

Rate of population increase depends mainly on rate of development, and on reproduction rate early in life. Both are high between 20° and 30° C.; reproduction is most rapid at 22° to 23°, development at

TABLE V.

ASSOCIATION OF TEMPERATURE AND APPEARANCE OF WINGED FORMS OUTDOORS.

Period	Mean Temperature, °F.	APHIDS BORN IN PERIOD, OF WINGLESS PARENTS	
		No. Reared	% Winged
1926.			
August 1 to 31.....	70.5	125	4.0
September 1 to 23.....	61.0	145	29.0
September 24 to October 31.....	48.5	21	0.0
1927.			
April 1 to May 24.....	51.0	30	0.0
May 25 to June 19.....	59.0	55	63.6
June 20 to July 15.....	72.0	34	14.7

30°. Increase is hence very rapid from 22° to 30° C., or roughly 70° to 85° F. At varying out-door temperatures the range will probably be a few degrees lower. Acceleration with alternating temperatures should allow rapid increase at an average of a little below 70° F.; and at varying temperatures averaging above 80°, maxima are likely to be injurious on hotter days. Results showing the depression of reproduction in the south in summer have already been cited. Population increase will be taken up more fully later.

EFFECTS ON PROPORTIONS OF BIOLOGICAL FORMS.

Ewing (1926, citing earlier work), Ackerman (1926), and the writer (Wadley 1923), all using *Rhopalosiphum prunifoliae* Fitch, have noted effects of constant temperatures on percentage of winged aphids. All found that unusually few winged forms appeared at 65° F., and unusually many at about 60° F., as compared with other temperatures. In the writer's work (1923), a constant temperature of 60° could not be conveniently attained; hence a slightly variable temperature averaging 62° F. was used.

In the outdoor insectary, winged forms of *Toxoptera graminum* appeared in considerable numbers, in spite of good nutrition, in spring and fall. The length of day differed in the two periods; and aphids reared in the greenhouse in higher temperatures, but the same day-length, in May and June, were not affected; hence it seems unlikely that length of day was the decisive factor. From results on other species of aphids, it seems that temperature variations might account for the increase of winged aphids.

It has not been possible to carry on a comprehensive investigation of influence of temperature on percentage winged. Some work has been done in bringing half-grown nymphs destined to be wingless, into various temperatures from 10° to 26° C., allowing them to mature and

TABLE VI.
TEMPERATURE AND PROPORTION WINGED IN LABORATORY.

TEMPERATURE, °C.	SECOND GENERATION		THIRD GENERATION		FOURTH GENERATION	
	Wingless	Winged	Wingless	Winged	Wingless	Winged
12	14	0				
14½	42	0				
17	41	0	20	1		
22	21	0				
27	7	0	24	0		
32	10	0				
Alternate—7 and 22	23	0	26	1		
Alternate—12 and 22	21	10	32	5	18	8

produce young, and rearing the young. All series were similar; very few winged forms developed. As it was seen that temperature influence did not appear strongly in the first generation, some were reared from birth under controlled temperatures; some of their progeny were then reared for a generation or more, using wingless parents. The results are given in Table VI.

The alternating temperature experiments were at the higher temperature 14 to 15 hours per day.

The temperature alternating between 12° and 22° shows a definite tendency to produce winged forms, and this accords with insectary results. Other temperatures have not shown such a tendency.

Temperature has some influence on the appearance of sexual forms, though shortened days seem to be the principal factor. High temperatures seem to prevent their development. They have appeared under moderate to cool temperatures, with shortened days; both in the outdoor insectary in summer, with days artificially shortened (Table XI), and in the greenhouse in fall and winter with natural short days (Table X). They have not appeared, except a few males, in the greenhouse

in summer, with artificially shortened days and higher temperatures (Table XI). They have not appeared with longer hours of light and cool conditions, either in the insectary (April and May) or in the temperature laboratory (Table VI). The highest temperature in which they have been produced averaged a little over 70° F. with minima occasionally below 60° F. With temperatures averaging 73° to 76° F., and minima usually above 65°, no oviparous females and only a few males have been reared. This was checked by parallel rearing in warm and cool greenhouses, averaging 76° and 66° F. in the fall of 1927. In the former, no sexual forms were reared among 109 aphids; in the latter, 20 out of 86 were sexual forms after the first two generations. When *Toxoptera* was moved from the cool to the warm greenhouse, no more sexes were reared after one generation. It appears that their development is retarded or prevented by cold as with other forms, since they failed to develop outdoors in the fall and developed in the greenhouse, just as did the parthenogenetic forms; Table III shows a few cases indicating retardation.

EFFECTS OF EXTREME COLD.

Some knowledge of the power of *Toxoptera* to endure cold has been gained from observations in the field, and from the literature. Viviparous forms seem to winter regularly in southern states, and less often as far north as Indiana. Where wintering occurs the temperature is high enough for slow development at times during the winter. Where 0° F. has been recorded, *Toxoptera* has survived only with protection, in the writer's observations. It seems likely that temperatures among plants on the ground are often not quite as low as recorded atmospheric minima.

In the insectary in November 1926, an adult and 7 nymphs died after 12 days continuously below 42° F., with a minimum of 8° F.; one remaining nymph survived 6 days longer, dying when —1° F. was reached. In November 1927, only one adult was carried into the winter; it died after 11 days below 42° with a minimum of 10° F. The pot-cages used gave practically no protection against cold. In an outdoor cage, considerably sheltered by snow and nearby buildings, the lowest winter temperature reached was 9° F. and the temperatures were usually between 20 and 30° F. Even here all of a colony of several hundred *Toxoptera* died before January, and colonies placed in the cage later in the winter died within a month. Similar results were obtained in an unheated greenhouse of about the same temperature range. Aphids were observed to withstand exposure to 8° or 10° F., but seemed unable to endure prolonged cold.

Observations under controlled conditions were carried out in the temperature laboratory. Preliminary experiments showed that all stages and forms were somewhat similar in resistance to cold; but that wingless parthenogenetic females were slightly hardier than large nymphs and winged females. Small nymphs were more variable than other stages. Only a few sexual forms were available; a male and 2

females proved unable to survive -11° C. for 3 hours, though some viviparous forms survived this. Of aphids hardened at 0° to 4° C. for 36 hours, then exposed to -12° C. for 2 hours, 13 out of 40 survived; of aphids fresh from the warm greenhouse, only 6 out of 80 survived. Aphids fed on plants hardened to cold but not themselves hardened, were as tender as those fed on non-hardened plants.

In later experiments aphids were hardened over night at 0° to 4° C. They were placed in vials (pre-cooled for the shorter periods) with bits of leaf, and put in a cabinet at the desired temperature. Vials were withdrawn at the end of various time intervals. For the sake of brevity, only critical points found are stated. Where the data do not yield the exact point, a range of time is given instead of an interpolated time. Table VII shows relations of time and fatal cold.

TABLE VII.
TIME AND FATAL COLD.

Temperature, °C.	°F.	Total No. Aphids Used	Maximum Time all Alive, Hours	Time About Half Killed, Hours	Minimum Time all Dead or Paralyzed, Hours	Minimum Time all Brown on Thawing, Hours
-23.3	-10	50	....	0.02 to 0.03	0.08 to 0.17	0.33
-20.6	-5	90	....	0.05	0.25	0.75
-17.8	0	54	....	.....	0.50	1.00
-16.1	+3	90	....	0 25	0.75	....
-15.0	+5	95	....	0 50	1.00	....
-12.2	+10	90	....	2 00	3.00	....
-9.4	+15	50	2	5 to 10	15 to over 20	....
-6.7	+20	146	21	72 to 96	120*	....
-3.9	+25	50	96	96 to 120	168	....
-1.1	+30	77	144 (6 days)	240 (10 days)	264 (11 days)	....
+1 to +3	+33.8 to +37.4	21	264 (11 days)	408 (17 days)	672 (28 days)	....

*Chimney cages instead of vials used for the longer periods.

It was found that when only part of a group of aphids was killed by cold, some of the survivors appeared normal but moved only feebly. They lacked coordination, and several trials showed that they always died in a day or two. These were counted as killed, in tabulating results.

The freezing point was taken with a thermocouple, by the rebound method, which is based on Bachmetjew's work (1901). A piece of glass tubing was sealed at one end, and filled with live aphids. The thermocouple was introduced, macerating the aphids more or less, and the mouth of the tube wadded with cotton. Several trials gave freezing points from -1.5 to -2.5° C. (29.7 to 27.5° F.). A second

but much less definite rebound, often represented only by a slowing up of temperature decline, occurred at about -14° C. When exposed to a temperature well below this point, all aphids turned brown on thawing, uniformly through the body. This indicates disruption of tissue or cells, perhaps associated with the lower rebound. At -12° to -16° C., some turned brown and some remained green, though dead or paralyzed; this may indicate individual variation. Above these temperatures they did not turn brown unless dead for some time. This lower rebound has a definite relation to time to kill at different temperatures; the higher, more definite freezing point has not (Fig. 4).

Webster and Phillips (1912) tell of eggs wintering successfully in Indiana; Washburn (1908-B) records finding some in Minnesota in the spring, most of which were dead, but a few of which hatched.

TABLE VIII.
TIME AND FATAL HEAT.

Temperature, °C. °F.		Maximum Time all Survived, Hours	Time Fatal to About Half, Hours	Minimum Time all Killed, Hours
41	105.8	.25	.33	.67
40	104.0	.50	.50 to 1.00	2.00
38	100.4	1.00	3.00	5.50
35	95.0	16.00	.....	.....

The writer secured 60 eggs of normal appearance in the greenhouse in November, 1926, on plants and on the chimneys used for cages. Some were kept in the insectary, exposed to temperatures reaching -20° F.; others were kept in an unheated greenhouse, the minimum being 0° F., and temperatures below 10° occurring only once. All failed to hatch in the spring. Dead embryos were found in some on dissection. Results were similar in 1927. Temperatures under six inches or more of snow were not below 12° F., seldom below 20° , and it would seem that some might survive with such protection. Eggs seem not to be fully hardy in Minnesota, though there is a possibility of some surviving.

EFFECTS OF EXTREME HEAT.

Experiments and records in literature showing depression of development and difficulty of rearing at high temperatures have been noted. Lefroy (1908) and Moore (1914) note difficulties in passing the summer in India and South Africa; they note a root-feeding habit in hot weather.

In one case a greenhouse compartment was accidentally heated to over 100° F.; some Toxoptera on oats growing in a flower pot standing on soil, left the plants and clustered on the soil under the pot. In another case, in a cage kept at 40° C., aphids left the plants for the soil; later, when the soil became dry, they returned to the plants.

Heat avoidance is evidently a well-marked feature of their behavior, and may be related to the root-inhabiting noted in hot climates.

In testing for a quickly fatal temperature a vial containing a thermometer and aphids on a green leaf, was placed inside a larger vial in a beaker of water gently heated. Above 30° C. the aphids were restless, and above 35° they often left the leaf, moving almost frantically as the temperatures rose farther. Their movements became aimless at 41° and ceased at 42°. Nearly all were revived successfully after one minute at 42°, but none survived 30 seconds exposure to 43° C. (109.4° F.).

All stages seemed to endure heat about equally except small nymphs. In one case at 35°, 8 adults and large nymphs all survived 16 hours while all small nymphs died. In tests, adults and large nymphs on pieces of leaf were put in vials which were placed in a Carrier cabinet. Table VIII shows relations of time and fatal heat.

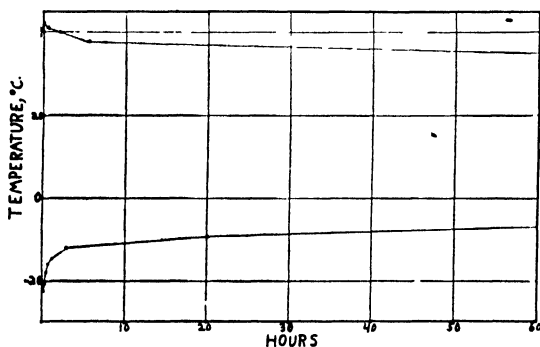


Fig. 4. Time and fatal temperature, laboratory results.

There is not a large class of apparently paralyzed aphids intermediate between those killed outright and survivors, with heat, as there is with cold. Some such have been seen, however. When paralyzed by heat, part may recover; of 24 placed on plants, 11 recovered.

Some trials were also made in putting pot-cages with *Toxoptera* on growing plants, in the cabinets; they did not die as quickly as in vials. All were killed in 14 hours at 40° C. At 34° to 38° adults lived one to several days and some reproduction occurred, as already noted. Colonies would quickly die out at such temperatures, as adults are short-lived and nymphs fail to mature. Thermometers were used within these cages. The cause of longer survival on growing plants is not known; it may be food or moisture supply, or lower temperatures on the leaf.

Fatal temperature and time are graphically shown in Fig. 4.

EFFECTS OF HUMIDITY.

Sap-feeding insects are evidently not likely to be directly affected by humidity; indirect influences result from the connection with precipitation and food supply. Adverse summer conditions are associated with low relative humidity. Headlee (1914) found *Toxoptera graminum* Rond. little affected by relative humidity ranging from 37 to 100 per cent.

No influence of humidity can be traced from greenhouse rearing and hygrographic records. In late spring and summer, day-length and temperature were favorable for reproduction; but humidity was lower in late spring owing to use of artificial heat. Reproduction and development were very similar in the two periods. In April and June, 1927, humidity averaged 48 per cent and 67 per cent, respectively, and little difference was observed. Greenhouse humidity averaged only about 30 per cent for over a month in the fall of 1927. The food

TABLE IX.
HUMIDITY AND ADULT ACTIVITY.

	IN MOIST CHAMBER—100%			OUTSIDE, COMPARABLE—50%±		
	No.Cases	Average	Range	No.Cases	Average	Range
Adult life.....	3	14.3 days	13 to 18	4	15.0 days	6 to 22
Total young...	3	22.7	12 to 36	4	29.2	18 to 37
*Reproduction rate per day..	4	1.8	.....	4	2.5	.....

*Based on reproductive period, not on total adult life.

plants did not thrive well, and were renewed often. *Toxoptera graminum* developed normally, except for the production of more winged forms than usual, which would be expected from the condition of the plants. A wet bulb thermometer reading, taken with great care in the type of latern globe cage most used, showed a relative humidity of 45 per cent as compared to 39 per cent outside, and indicated that cage conditions were much like those outside.

Table IX gives a summary of rearing results, in a moist chamber with saturated air, in the greenhouse in the late winter of 1927; compared with rearing just outside in a humidity of about 50 per cent. The parents used in the moist chamber were sisters of those used outside in a regular generation series.

The reproduction rate in the extreme humidity was somewhat depressed; the exact time required for development was not secured, but it did not differ greatly from the check.

The species seems practically unaffected by moderate variations in relative humidity and but slightly affected by extreme variations.

EFFECTS OF LIGHT.

Toxoptera graminum has been reared with ease in natural light coming through wire screen, cloth, mica, and common glass. In the temperature laboratory, large numbers and consecutive generations have been reared without much difficulty by both ordinary tungsten lights and nitrogen-filled "daylight" bulbs, although food-plants did not thrive very long. The species has done well in every light tried which was favorable to its food plants. No experiments on quality of light have been carried on. More than 50 generations of *Toxoptera* have been reared under glass, and oats have yielded viable seed in

TABLE X.
REPRODUCTION AND DAY LENGTH.

Month	No. Reared During Month	Percent Sexes Among those Maturing	Percent Winged	Reproduction Rate Per Day, Average	Average Temperature, °F.	Average Day-length, Hour
January.....	125	23.2	8.8	1.9	68.5	9.3
February.....	152	13.2	16.4	2.3	72.5	11.3
March.....	75	6.7	32.0	1.7	71.0	11.7
April.....	104	0.0	1.0	3.1	72.0	13.6
May.....	187	0.0	1.6	3.5	74.5	14.3
June.....	184	0.0	5.4	3.7	76.0	15.5
July.....	224	0.0	2.7	3.6	75.0	15.2
August.....	144	0.0	0.0	2.9	73.5	14.0
September.....	140	0.0	22.9	2.6	73.0	12.8
October.....	184	6.0	13.6	1.7	70.0	10.9
November.....	180	30.0	12.2	1.8	71.5	10.0
December.....	43	34.9	2.3	1.7	69.0	8.7
April to August, inclusive.....	.....	.....	.....	3.4±0.084	74.2	.....
October to March, inclusive.....	.....	.....	.....	1.8±0.055	70.4	.....

quantities; hence it may be said that daylight coming through window glass is sufficient for the needs of this aphid and its food plants.

The quantity of light per day is important. Garner and Allard (1922) did pioneer work on connection of day length and reproduction in plants. Marcovitch (1924) and Shull (1926, 1927) show that sexual forms appear in several aphid species in response to shorter light periods; also that winged forms are more numerous with less light. Davidson (1924), using *Aphis rumicis*, reared sexes in the greenhouse in winter; they failed to appear when the day was lengthened by artificial light. Washburn (1908-B) noted smaller families of *Toxoptera graminum* Rond. in winter, in greenhouse rearing; Hunter (1909) found reproduction reduced when the sexes were developing.

In the present work, sexes did not appear in outdoor rearing, development apparently being checked too soon by cold, but did develop in the greenhouse all through the winter.

In Table X are given rearing records, in the greenhouse from September 22, 1926 to September 12, 1927. The daily reproduction rate of all wingless females is included. Winged females did not produce sexual progeny in the present work. The rate all through adult life is used, as it seems as comparable for this purpose as that early in life and gives more records. A few females caged on wheat during the winter are included. They differed little from those on oats in the matters considered, though shorter lived. Temperature records were taken with a hygrothermograph most of the time; bi-daily thermometer readings and a recording thermometer were used for short periods in the fall. Day lengths are calculated from data for St. Paul in U. S. Weather Bureau Bulletin Q.

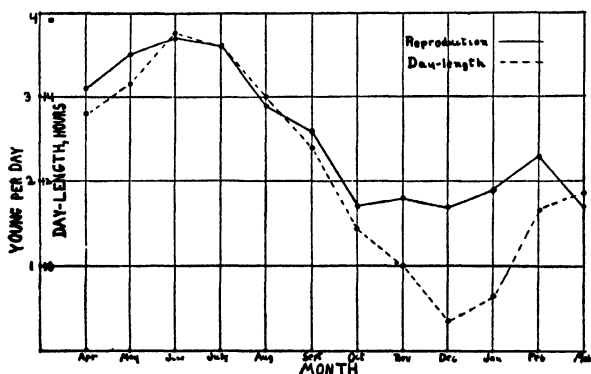


Fig. 5. Average reproduction in greenhouse, and day-length, by months. (Temperature varied but little.)

The association of day length with reproductive rate through the year is graphically shown in Figure 5; with percentage of sexes in Figure 6. It has been found that sexes do not appear until a few weeks after conditions become favorable, and continue to appear for a short time after the favorable conditions are removed.

Sexual forms also appeared in greenhouse rearing in fall and early winter, 1927. Winged females produced no sexual progeny; three in spring and summer averaged 2.5 young per day and a total of 37; four in winter averaged 1.6 per day and a total of 29.

It will be noted that the reproduction rate from October to March is lower than that from April to August, and that the difference is very significant and too large to be explained by the small difference in temperature. The differences between months within each period are usually not significant. September seems definitely transitional as to reproductive rate, especially in the latter part, and is omitted from the comparison. Thirteen females in the greenhouse in fall and winter show almost exactly the same length of life and reproductive period as 19 in spring and summer. The total number of young is much smaller in the former period, being proportional to the reproduction rate. The time required for development was longer in the winter period

(10.0 days \pm .363 as compared to 7.4 \pm 0.153), but the difference may not be significant when allowance is made for the difference in temperature.

Experiments in day-shortening, darkening pot-cage colonies of *Toxoptera* part of the day by inverting large flower pots over them, were conducted in the summer of 1927. For two months a maximum and minimum thermometer was kept under the cover; this was discontinued when it was found that the temperature differed very little from that just outside. Experiments showed that feeding and reproduction took place in the dark. For days of 8, 9, and, in a few cases, of 10 hours, covers were put on in the afternoon and removed in the morning; in other experiments they were put on in the afternoon and

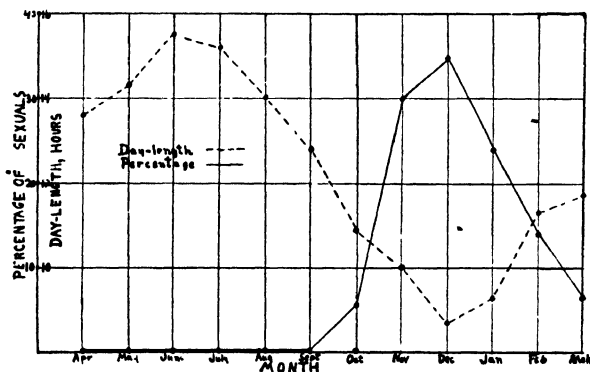


Fig. 6. Day-length and percentage of sexual forms among those reared in greenhouse, by months.

removed after dark the same evening, so that the cages were covered only a few hours and were exposed to normal dawn. Consecutive generations were reared in each day-length, so that the line was kept under the given conditions; wingless parents were used. The 9-hour day was run in the insectary, with temperatures averaging a little above 70° F., and minima often below 60° F. The others were run in the greenhouse, with temperatures averaging about 75° and minima seldom below 65°. These higher temperatures appeared to prevent production of sexes, as already stated. In the insectary with a 9-hour day, both sexes were reared in July and August. Data from these experiments are shown in Table XI. Data on proportion of forms includes in some cases one generation after treatment ceased, as it was found that its effects persisted in one generation.

It is concluded that days shortened beyond a certain point produce a definite drop in reproduction rate, and associated with this at suitable temperatures is production of sexual forms. This point appears to be between 11 and 12 hours, and notes indicate that with natural day-length it is near 12. The drop in reproduction begins at once after the days are shortened; sexes do not appear until two generations later. Tables X and XI and Figure 5, suggest that the reproduction rate

does not vary much from 8 to 11 or 12 hours, or from 14 to 16 hours, but that there may be some gradient in rate from 11 or 12 to 14 hours. Data are not yet sufficient to determine whether percentage of sexes varies with day-length, below 12 hours.

Winged forms show an increase with 8- and 9-hour days; these results are similar to Shull's (1927); they also showed a marked increase at 12½ hours. The latter tendency is reflected in greenhouse results in March and September; but in September the winged forms were largely among some brought in from outside at the start, hence were influenced by temperature also.

The effects of day-length on development of the sexes is important in studying the economic status of the species, and its effects on develop-

TABLE XI.
REPRODUCTION WITH ARTIFICIALLY SHORTENED DAY.

Day-length, Hour	Period	Place	Reproduction Rate Per Day	Total Number Reared	Males, Percent	Oviparous Females, Percent	Winged Females, Percent
8	April 25-Aug. 2	Greenhouse	2.3	129	2.3	0.0	35.6
9	June 25-Sept. 12	Insectary	2.2	350	2.6	6.3	39.4
10	Aug. 1-Oct. 31	Greenhouse	2.3	286	0.3	0.0	13.3
11	Aug. 1-Oct. 20	Greenhouse	2.9	157	3.2	0.0	20.4
12	Aug. 1-Sept. 30	Greenhouse	3.3	107	0.0	0.0	0.9
12½	Aug. 1-Sept. 12	Greenhouse	3.0	206	0.0	0.0	56.8

ment of winged forms may also be of some importance. The drop in reproduction with short days does not appear to be of importance in the field, as short days occur only when cold slows up or prevents reproduction. It is important, however, in interpreting results of greenhouse rearing in winter, with natural light. It may well be asked if cloudiness alters the day-length effective in producing sexes; fragmentary data indicate that such may be the case. Kelly (1917) found no sexual forms in the field in northeast Kansas, in 1907, but found some in 1908; Hunter (1909) reared them late in October, 1907, and early in October, 1908, in the same region. They were more abundant in the field in Indiana in 1908 than in 1907 (Webster and Phillips, 1912). The fall months, especially September, were cloudier in 1908 than in 1907 in both areas (Monthly Weather Review). Sexes appeared over considerable periods of both decreasing and increasing day-length, indicating that the length and not the change of length is the important factor. It is obviously not entirely dark at night in the greenhouse; the effective shortening of the day must be due not to long night periods of absolute lack of light, but to periods of light below a certain critical intensity. Cloudy conditions may increase the length of that period of the day below this intensity, thus lengthening the effective night.

EFFECTS OF VARIOUS WEATHER PHENOMENA.

RAIN.

An apparent association of outbreaks of *Toxoptera graminum* with dry weather, and apparent diminution in numbers during rainy spells, suggested investigations as to the cause. High humidity proved not to be very detrimental; several authors cited have mentioned decrease due to rain. Of two areas, one sprinkled three times a week and one not sprinkled, in a bed of oats in the greenhouse, *Toxoptera graminum* increased in the unsprinkled area and barely persisted in that sprinkled.

TABLE XII.
EFFECT OF SPRINKLING ON NUMBERS.

Numbers	Small Nymphs (1st and 2nd instars)	Large Nymphs	Adults
Before sprinkling.....	127	92	50
After sprinkling.....	84	53	29
Succumbed.....	43	39	21

The sprinklings were faster than natural rainfall, $\frac{1}{4}$ inch of water being given in less than a minute. In 3 cases colonies in pot-cages were sprinkled and counts made.

TABLE XIII.
EFFECT OF RAINS ON NUMBERS.

Experiment	Date	Kind of Rain	No. of TOXOPTERA		No. on Checks
			Before	After Rain	
First.....	May 12	Moderate shower.....	39	17	43
"	" 12	Hard rain, hail.....	17	None seen	43
"	" 19	Fine misty rain.....	15	11	162
"	" 27	Moderate shower.....	73	45	Plants dead
Second...	July 3	Hard shower.....	166	106	54
"	" 13	Hard shower.....	.....	338	347
"	" 16	Hard shower.....	.....	243	419
"	" 23	Several light showers...	.....	125	609
"	" 28	Several light showers...	.....	8 (heading)	126 (injured)

The action of sprinkling water being established, tests were made by exposing large pots of infested oats to actual rains. Two experiments were made, in May and July. Checks not exposed to rain were run.

In the first test small oats were used; in the second, larger plants, of 3 leaves, growing vigorously. The plants exposed to rain in the second test headed normally, aphids leaving at about heading time,

while the check plants were killed by *Toxoptera* after becoming 8 to 10 inches high.

In small oats, *Toxoptera* may be almost entirely controlled by rain; but in 2 weeks with little rain, as from May 12 to 27, considerable injury may develop. In larger and denser growth complete control will not occur, but rain may hold back infestation. Rains 2 or 3 times a week probably hold *Toxoptera graminum* well in check. Aphids washed off are often found partly buried in the mud; others are able to regain a footing, and still others are doubtless completely buried. Equal rains probably have a stronger controlling action in cool than in warm weather, because losses are replaced by reproduction more slowly. Glenn (1909) mentions winter rain as especially detrimental.

SNOW.

Webster and Phillips (1912) record successful survival of cold spells by *Toxoptera graminum* with snow protection. In several cases a lantern-globe pot-cage with oats infested with *Toxoptera* was filled with snow sifted gently in, and set in an unheated greenhouse with the temperature near freezing. On thawing, survival was observed (Table XIV).

TABLE XIV.

TIME UNDER SNOW	SURVIVED
1 day.....	Part
2 days.....	Part
16 hours.....	12 out of 20
10 days.....	1 out of 18
18 days.....	0 out of 20

Covering with snow is not of itself fatal to all the aphids, though some stick in the mud on thawing. It may enable the species to pass short periods of severe cold. Temperatures under snow are surprisingly mild; a recording thermometer showed that in 1926-27, under 6 inches or more of snow, the temperature was usually between 20° and 30° F., with a minimum of 12° F., at St. Paul. However, in Minnesota the cold is too prolonged for survival under snow, as *Toxoptera graminum* dies in a few weeks even at the freezing point.

WIND.

Field observations, and a few greenhouse experiments with an electric fan, indicate that *Toxoptera* thrives in windy localities as well as sheltered ones; except that cold weather can be withstood better with shelter. The most important effect of the wind is as a stimulus and an aid to migration. Some observations were made by the writer and others in Minnesota in 1926.

Toxoptera graminum was seen flying north, southeast, and west, in every case with the wind. F. C. Hottes and T. S. Aamodt, graduate

students, saw swarms of the aphids rise from infested grain as a breeze sprang up, settle as the breeze died down, and rise as it blew once more. Webster and Phillips (1912) and other workers have observed association of flight with wind; Kelly (1917) notes that they change direction when the wind shifts. *Toxoptera* seems a weak flier in still air, but appears to fly with little effort in a moderate wind. The Chitrovo soaring coefficient (Collins 1915) is about 135 for the winged form; this compares with about 500 for young gipsy moth larvæ, which are easily transported by wind, and the surface of winged aphids seems well arranged for buoyancy in an air current. These observations indicate that the species is largely dependent on the wind as to direction and distance of flight.

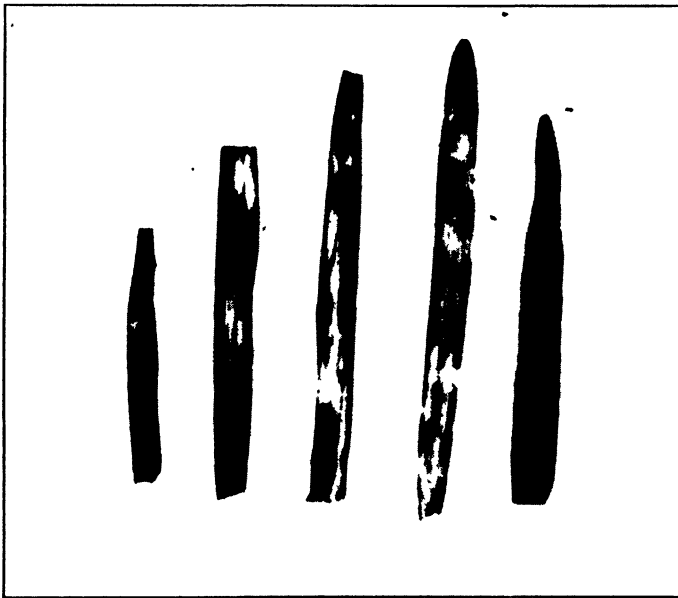


Fig. 7. Oat leaves in varying stages of injury from feeding of *Toxoptera*.

FOOD RELATIONS.

Under this heading may be considered injury caused by feeding, plant species furnishing food, reaction to food plants, and other nutritional factors.

INJURY.

This species is much more injurious in proportion to its numbers than other grain aphids observed. Its feeding causes a peculiar and characteristic injury to its food-plants, (Fig. 7), which has been studied

by the writer (Wadley, 1929). Pale spots with red centers developed around feeding punctures. Injury invariably followed prolonged feeding and was roughly proportional to amount of feeding. Neither recovery, nor spread for long after feeding ceased, was observed. Injury was similar on various food plants. Paleness was apparently due to destruction of chlorophyll, while red spots were caused by reddening of the leaf-cell nuclei. A water extract of frozen *Toxoptera* slowly decolorized a solution of refined chlorophyll. After heating the extract lost this power. It seems likely that an enzyme produced by the aphid is the cause of the destruction of chlorophyll.

FOOD PLANT SPECIES.

Webster and Phillips (1912) list about 60 food plants; a few others are mentioned by Hunter (1909), Moore (1914), and Van der Goot (1915). All the food plants recorded are of the grass family, with rare exceptions. They include the common small grains, rice, corn, sorghum, millet and many annual and perennial grasses. Few direct statements are found in the literature as to the degree of infestation of different species. By far the majority of serious infestations recorded have been on oats and wheat. In some cases injury to barley and rye has been recorded. Young corn (Kelly, 1917) and sorghum (Hayes, 1922) have been temporarily infested by *Toxoptera* leaving dying oats or wheat nearby, but are usually not attacked. Bluegrass (*Poa pratensis*) has been injured in a few cases (Webster and Phillips, 1912; Garman, 1926) and seems to be a favorable host. Orchard grass (*Dactylis glomerata*) is mentioned by several workers, and Johnson grass (*Sorghum halapensis*) by Moore (1914), as favorable.

In the present work severe injury to oats and wheat has been seen; barley and rye have not been observed to be infested except when close to heavily infested wheat and oats. *Toxoptera graminum* has been found on wild oats (*Avena fatua*) in the field; small numbers have been found on bluegrass, corn, quack grass (*Agropyron repens*) and pigeon grass (*Setaria glauca*), when near infested grain. The species has been reared with some difficulty on *Muhlenbergia* sp. probably *racemosa*, which is probably a new food plant record. Many other grasses have been observed without finding *Toxoptera*.

The species can be accounted for throughout the year on the grass family; the sexes are produced readily on these plants, and no evidence has been found of other host plants alternating with grasses.

REACTION TO FOOD-PLANTS.

The survey of the literature and the field observations noted would indicate that injury is greatest to oats and wheat, and that other plants are infested to a small degree. The insect has often been injurious from the Carolinas to Texas and Oklahoma, and sometimes in the regions to the north. The outbreak of 1926 extended to the Dakotas, Minnesota and Wisconsin. Injury in all these regions would imply that oats of most common cultivated types, both winter and spring varieties of *Avena sativa* and *A. sterilis* (Rustproof type); and

common wheat of hard winter, soft winter and hard spring types, have been injured; since all are widely raised in some parts of the region.

Minota, a white variety of oats, has been used in general rearing. In several hundred cases there has seldom been a failure to increase rapidly on it; a majority of nymphs born have matured and over 60 consecutive generations have been reared. Minturki, a hard winter variety of wheat, was also used for about 8 months with similar results. Reproduction was as rapid as on Minota oats, but adult life was shorter, families were smaller, and development appeared to be a little slower. The oats seemed to be somewhat better suited for the aphid than the wheat, though the difference was not great. Several other varieties of

TABLE XV.

Plant Species	Number Trials	CASES IN WHICH				Duration of Colonies, Days
		FIRST GENERATION		SECOND GENERATION		
		Was Born	Matured	Was Born	Matured	
Rye.....	8	4	1	1	1	1 to indefinite
Barley.....	7	3	1	1	1	2 to 29
Corn.....	1	0	0	0	0	2
Sorghum.....	1	1	0	0	0	3
Bluegrass.....	14	12	6	6	6	1 to indefinite
Orchard grass..	4	4	2	2	1	2 to 56
Elymus canadensis...	2	2	1	0	0	2 to 12
Bromus inermis	1	1	1	1	0	26
Muhlenbergia..	6	5	3	2	2	1 to 42
Quack grass....	6	1	0	0	0	2 to 11
Pigeon grass...	2	1	1	1	0	5 to 34

oats, representing the Kherson, Rustproof, and Gray Winter types; and of common wheat, representing hard spring, soft red winter, and white types, were tested in a single set of experiments in pot-cage rearing. On all these, adults reproduced rapidly, half or more of the first generation nymphs matured, and a large and vigorous second generation killed the plants. On Little Club, a variety of the club type of wheat, often regarded as a subspecies, results were similar. On Mindum, a variety of the durum subspecies of wheat, and on common wild oats, rearing was somewhat difficult, less than half the nymphs maturing; but the second generation killed the plants. On Vernal, a variety of the emmer subspecies of wheat, the aphids refused to thrive; less than 10% matured, and no second generation developed.

Some other grains and grasses were tested. These included seedlings of corn, barley, rye, sorghum, *Bromus inermis*, and orchard grass; and transplanted bluegrass, quack grass, *Elymus canadensis*, pigeon grass, and Muhlenbergia. One to four adults were caged on the plants in each trial. On all these plants rearing was more difficult than on

oats and wheat; colonies often failed to become established or died out, total numbers reached were usually small, and plants were seldom killed by the aphids as with wheat or oats. Figure 8 shows graphically numerical increase in the most successful cases of rearing on bluegrass and Muhlenbergia as compared with an ordinary case on oats. Table XV outlines rearing results with these plants.

Barley and corn seedlings near heavily infested oats in greenhouse beds were attacked, but not colonized nor permanently injured. Barley seedlings among heavily infested oats in a tight cage were fed on till they wilted. Barley was peculiar in showing the typical Toxoptera injury but little; faint spots appeared, however, from prolonged feeding. Common six-row barley was used in most of the work, but in two trials a two-row variety was used; it did not differ much from the six-row. Bluegrass is a variable species (Piper 1924), and the variability seems to extend to suitability for Toxoptera. Several plants of ordinary appearance gave moderately good results in rearing, one not distinguishable from them gave more favorable results than the average, and on still another of similar appearance repeated trials ended in failure.

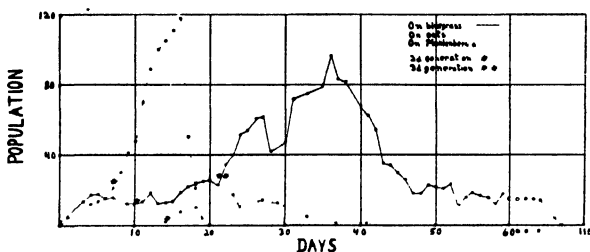


Fig. 8. Population increase on several food-plants.
(In greenhouse, temperature similar for all.)

A plant with finer blades than usual gave poor results while on a coarse-bladed one rearing was fairly successful. On timothy (*Phleum pratense*), red-top (*Agrotis alba*), crab grass (*Syntherisma*) and a barnyard grass not determined, feeding and reproduction were not observed in cages or near infested oats.

Plants studied may be tentatively divided into four classes. On preferred food-plants, rapid reproduction may continue indefinitely. Injury is obviously likely if multiplication is unchecked. Most types of wheat and oats studied will fall in this class, though some differences will be found among them. The next group may be termed second-choice food-plants; on them reproduction and growth are possible, but more or less restricted. Colonies are formed, but are often short-lived; on the other hand, individual plants sometimes live and remain infested a long time, because the aphids increase slowly. The chance of reaching injurious numbers is plainly not great. Orchard grass, Muhlenbergia, rye, the favorable types of bluegrass, and probably barley, emmer, *Bromus* and pigeon grass should be included from present data. The third class may be termed temporary food plants; feeding occurs, and there is a tendency to remain for a time, but repro-

duction is exceptional. From these experiments corn, sorghum, Elymus, quack grass, and some types of bluegrass should be included. Plants of this class may be injured when young if over-run by *Toxoptera* leaving nearby oats or wheat. On the fourth class *Toxoptera* has refused to remain long; timothy, red-top and other species should be included. Field observations and literary records agree in a general way with conclusions.

The only factors known to explain scarcity or abundance on different host species are increased restlessness and decreased growth and reproduction on the less suitable plants. The writer has not been able to detect sensory discrimination. Winged and wingless adults did not distinguish between barley and oats at first contact. White clover was fed on at first, though the aphids left in an hour or two. Hunter

TABLE XVI.

FACTORS IN SLOWER INCREASE ON DISTASTEFUL FOOD PLANTS.

Food-plant	Time Remained Adults from Oats, Days	ADULTS REARED ON PLANTS				
		Nymphal Period, Days	Average Size, mm.*	Reprod. Rate per Day	Reprod. Period, Days	Per- centage Winged
Rye.....	1 to 5	11 to 14	1 33 x .60	0 9	4 to 10	.....
Bluegrass.....	1 to 9	10 to 11	1 23 x .51	1 4	3 to 10	39.7 (of 68)
Elymus	1 to 10	about 11	.....	.....	.....	.....
Orchard grass..	1 to 5	9 to 10	1.22 x .50	.....	3 to 10	65.9 (of 44)
Muhlenbergia ..	1 to 9	11	.....	1.6	1 to 9	80.0 (of 5)
Pigeon grass..	5 to 7	about 15	very small	0 7	3	.....
Bromus.....	1 to 5	8 to 9	1 35 x .42	1 3	2 to 4	.....
Oats, Compar- able Cases ..	12 to 42	8 to 9	1.80 x .80	2.5	12 days or more	23.1 (of 117)

*Length and greatest width of live aphids.

(1909) records *Toxoptera* piercing toadstools; in this work one was seen attempting to feed on a pencil. The aphid feeds when it settles on a new plant, and leaves if the nutrition proves unsatisfactory.

The tendency to leave unsuitable food-plants, or to fail to thrive on them, is shown by Table XV. Large nymphs and young adults have been found dead on barley, rye, emmer, durum, wild oats and orchard grass. Decreased reproduction was partly caused by shortened reproductive period of the parents; these often reproduced at a normal rate for 1 to 3 days when put on unsuitable plant species, then nearly ceased reproduction, and left or died after a few days. It was also caused by the difficulty the new nymphs encounter in living on the plants, expressed in decreased percentage maturing, slower development, smaller size and lower rate of reproduction when mature. As the colonies became older winged adults, restless and not very prolific, became numerous. Data concerning these factors is brought together in Table XVI.

Many food plant records in the literature were probably made at times of great abundance and migration, when many species of plants were more or less briefly infested. A number of those should probably be classed as second-choice or temporary plants.

OTHER FACTORS.

Limited nutrition usually results in an increased percentage of winged aphids (Gregory, 1917; Wadley, 1923; Ackerman, 1926; Reinhard, 1927). With *Toxoptera graminum*, young nymphs born of wingless parents were confined in vials without food for given periods during development. They were carefully restored to the plants after starvation. This lowered the amount of nutrition (as they feed almost constantly when on the plant) without changing its quality. Several 8- and 16-hour starvation periods early in life did not increase the percentage of winged forms; even 24-hour periods were ineffective,

TABLE XVII.
LIMITED NUTRITION AND PROPORTION WINGED.

	Total Number	Percent Winged
Nymphs, nutrition limited early in life.....	89	21.5
Checks.....	138	27.5
Unstarved progeny, of wingless adults starved early in life.....	35	82.9
Unstarved progeny, of wingless parents starved just before birth of offspring.....	73	69.9
Checks.....	77	15.6
Unstarved progeny of winged parents starved as above.	21	4.8
Checks.....	19	0.0

though they killed some nymphs. The progeny of wingless aphids starved when young, however, when reared with good nutrition, showed a high percentage winged. The effect of transferring to undesirable oat plants when quite young was next tried; also combinations of feeding on poor plants with starvation periods. These methods showed results, similar to those of starvation alone.

Some aphids were starved by confinement in vials for 16 hours, shortly before progeny were born. Wingless nymphs about to mature, then wingless adults were tried. Their progeny reared on favorable plants showed a marked increase in winged forms, even when parents were starved for only one period the day before their birth. Starvation of winged adults, however, gave negative results.

Confinement in vials stops reproduction at once, but it is resumed within a few hours after restoration to the plants.

Poor nutrition may result from the food-plant being in poor condition, approaching maturity, or being of an unsuitable species, as well

as from complete deprivation of food. Reproduction on unfavorable species has been discussed. It has often been noticed that many winged forms develop on overcrowded and failing plants, and that reproduction is checked and nymphs with wing-pads appear as oats and wheat are heading.

Wingless adults reared with ample nutrition but placed on the test plants just before maturity were allowed to produce young. The rate of reproduction, and number of winged among the progeny, were noted. Some wingless progeny were later placed on favorable plants and their progeny reared. Results appear in Table XVIII.

TABLE XVIII.

REPRODUCTION AND PROPORTION WINGED ON UNFAVORABLE PLANTS.

Plants	Reproduction per Day, Parents	FIRST GENERATION OF PROGENY		SECOND GENERATION (Favorable Nutrition)	
		Total Number Reared	Per- centage Winged	Total Number Reared	Per- centage Winged
Healthy oat seedlings.....	3.1	69	10.1	*	*
Same, but with dry soil.....	3.3	53	15.1	18	66.7
Seedlings, injured by previous Toxoptera feeding.....	2.9	33	24.2	50	86.0
Oat seedlings, unthrifty.....	3.1	34	20.6	28	42.8
Large plants, in joint, 4 leaves..	3.3	70	21.4	28	21.4
Large plants, heading.....	3.2	13	15.4	21	28.6
Large plants, heading, later trial.....	.....	.....	.....	52	75.0
Young plants, check later trial..	.....	.....	.....	52	25.0

*The first generation on healthy plants served as a check, as the aphids had been reared on such plants for several previous generations.

Daily reproduction was not much affected by varied nutrition, but adults soon left the heading plants and those classed as unthrifty. On these and on injured plants fewer nymphs matured. On the heading plants, only 13 out of 32 matured in the first trial; development was slower and the new adults were smaller than on others, and behavior in general was similar to that on second choice food-plants. These plants alone survived the experiment in good condition. It is of interest to note that plants just heading are less suitable for the aphids than younger plants, as at the heading stage they appear green and tender. The large plants just jointing, on the other hand, were still suitable.

It is concluded that all forms of curtailed nutrition produce a high percentage of alates; that the effect is seen in the succeeding generation. Curtailed nutrition, if severe, may be effective in wing-production as late as a day before birth, but is not effective after birth. Poor nutrition

seems not to affect rate of reproduction of vigorous aphids much unless it is severe, when it tends strongly to stop reproduction altogether. With plants of suitable species and age, but unhealthy, many winged forms develop and migration occurs; it may be hastened by collapse of plants. Factors influencing numbers on unsuitable plant species have been discussed; they appear to be similar with suitable species becoming too mature.

APPEARANCE OF BIOLOGICAL FORMS.

Having considered relations to physical factors, including nutrition, it is desirable to consider several subjects having to do with survival and increase of the species. These factors are characteristic of the species itself, though they are modified by environment, and are discussed under environmental conditions; they fall under the heading defined by Chapman (1925) as biotic autecology. First to be considered is the appearance of biological forms. These different forms are fundamental to the ability of aphid species to migrate and withstand the seasons.

Some factors affecting their proportions have been treated. They will be briefly brought together. Relations of the sexual and parthenogenetic forms, and of winged and wingless parthenogenetic females, are characteristic of the family. These relations might be expected to be governed by the same general principles throughout, with minor specific differences.

WINGED AND WINGLESS FEMALES.

Differences between winged and wingless females seem less deep-seated than those between parthenogenetic and sexual forms. Wingless females are more abundant under favorable conditions. It is possible to rear nearly 100 per cent wingless regularly. Ewing (1926) has reviewed most of the recent work on factors affecting proportion of winged and wingless aphids.

The effect of parentage is pronounced with *Toxoptera graminum* Rond., as with other species. In the first year's insectary and greenhouse rearing, 293 young were reared from 15 alate parents; all but one were wingless. At the same time, progeny was reared from 67 wingless parents; 36 had from a few to 75% winged among their progeny, 31 had none. Of the entire progeny of the 67, about 12 per cent were winged. Winged parents produced nearly all wingless progeny even when nutrition was limited.

It has been shown that limited or unfavorable nutrition when endured by wingless aphids greatly increased the proportion winged among their progeny. A variable temperature averaging about 60° F. was associated with an increase of winged forms both in insectary and laboratory, as was a day-length of about 12½ hours; these indications are less clear cut and rest on fewer data than the conclusions as to effect of nutrition, and more work on the subject is desirable.

Brittain (1921), and Reinhard (1927), emphasize overcrowding as a factor increasing the proportion of winged aphids, and publish evidence that it has an influence independent of that of nutrition. It is hard to separate these influences; with *Toxoptera graminum* it is practically impossible, as a plant or part of a plant crowded with *Toxoptera* would be dead in a few days.

It is clearly established that the winged form of *Toxoptera* has a strong tendency to produce wingless progeny, and is little influenced in this by environment. The wingless form may produce 100 per cent wingless or nearly 100 per cent winged, and the percentage may be modified by environmental conditions. Limited nutrition gives the most positive results in increasing the proportion of winged forms and may produce them at any time in the season. The temperature effect observed would tend to produce migrants in the field at somewhat definite times in spring and fall, while the day-length effect would tend to produce them in September. The winged females seem to be inherently migratory, and any factor producing them is a cause of migration.

As observed before, with *Toxoptera* wing-production factors are not effective after birth, but must be applied to the parents. This agrees with results on the pea aphid (Gregory, 1917), and the potato aphid (Shull, 1927). However, with the melon aphid (Reinhard, 1927), the apple-grain aphid (Wadley, 1923 and others) and several other species (Shinji, 1918) wing producing factors may be effective after birth. The young, at least of wingless parents, must all be potentially winged; and some internal conditions, influenced by external factors acting before a certain critical stage, must govern wing development. Ackerman (1926) has studied internal difference in nymphs of the apple-grain aphid. With wing development are associated several morphological and physiological differences.

SEXUAL FORMS.

Work on the history of the germ-cells of various aphid species, some similar to *Toxoptera* is summed up by Wilson (1925). It is found that males differ slightly from females in chromosome number, and that the difference comes about in maturation. The oviparous female does not differ from parthenogenetic females in chromosome number; her ovaries are different, and she must be determined early in development. Stevens (1905) found maturation stages in well-developed aphid embryos; in a young female not quite mature containing large embryos, maturation of individuals two generations ahead may be taking place. If *Toxoptera graminum* resembles the species she used, which seems probable, factors producing sexual forms must be at work about two generations before the forms appear.

No environmental factors other than day-length and temperature have been observed to influence the production of the sexes. They have appeared under natural days of less than 12 hours, and artificially shortened days of 11 hours or less. Both sexes have appeared when the temperature averaged 70° F. or less; above this, only a few males

developed. These forms appeared each time these conditions of temperature and light were fulfilled. Day-length seems the dominant factor; the rearing of a few males with short days and high temperatures show a tendency to produce sexuals, but with long days and favorable temperatures no such tendency appeared. No influence of food-plants was seen, except that the two sexes were about equal in number in the line on oats, and twice as many females as males occurred on wheat. All sexes reared were the progeny of wingless females; none were found among 138 aphids reared from winged parents, in the greenhouse from October to March. (Compare wingless parents, Table X).

A few further facts may be recorded concerning these forms. They were not produced before the second generation, born under favorable conditions, and have not matured earlier than about a month after the onset of these conditions. This conclusion is drawn from 5 sets of experiments. They continued to appear in one generation after favorable conditions had been removed, in 7 experiments; in the second generation after conditions changed none were reared in 3 trials. Males and oviparous females appeared at the same time in the greenhouse in two winters, and in the insectary in midsummer when the days were artificially shortened. Of 12 families having 5 or more sexual forms, 9 included both males and females. Males appeared under a wider range of conditions, however, and might conceivably be produced without oviparous females. The majority of aphids were parthenogenetic even when sexes were developing; in the winter of 1926-27 in the greenhouse, about 20 per cent were sexes. Of 15 families of 20 or more aphids in this period, only one had no sexes, and only one had a majority of them. The sexual forms were often, but not always, among the later-born members of a family.

No evidence of reduction of vigor by continuous parthenogenetic reproduction, as suggested by Luginbill and Beyer (1918) is seen after over 60 generations. Comparable generation rearing in two years was done in the insectary in August and in the greenhouse in October. August results on reproduction and development show slightly more vigor in 1926 than in 1927; October results just the reverse. Temperature laboratory rearings in early summer, 1927, and late fall, 1927, with similar conditions, give nearly identical rates of reproduction.

Factors affecting production of sexual forms may limit their distribution; this will be discussed later.

MIGRATIONS.

The power to migrate is necessary to continued existence when food-plants ripen or die, and is of considerable advantage to the species by keeping the individuals well distributed on favorable plants.

The development of winged females, often termed migrants, is the first step in any extended migration. These are more restless than wingless females, and data at hand indicate that they often leave plants even when nutrition is satisfactory. Seven out of 15 winged

adults used in rearing were missing after producing 3 to 15 young, which was less than half the average for those kept till death. With wingless females only 13 out of 67 were missing so early in the reproduction period. Migrants just arrived were found in the field with small groups of young; a few days later, groups of half-grown young were found without adults, and winged adults with smaller young were seen on nearby plants. Wingless adults and large nymphs usually remain on satisfactory plants throughout life; but they have been observed many times to leave unfavorable plants. The small nymphs leave the plants less readily, and are usually the last to be found on dying plants. The sexes are very restless and difficult to keep caged; their wanderings may be useful in bringing them together, as they have not appeared to recognize each other more than a few millimeters away.

Rhopalosiphum prunifoliae Fitch, another common grain aphid, has been observed to have a much greater tendency than *Toxoptera* to leave the food-plants and seek others; it also produces the winged form more quickly under adverse nutrition (Wadley, 1923). *Macrosiphum granarium* Kirby seems to be intermediate in this respect. The greater tendency to concentrate its feeding may be one reason for the economic importance of *Toxoptera* as compared with these species.

Migration by walking has a limited importance; even winged females have been seen to travel by walking more often than by flight. Plants have become infested in the greenhouse by wingless aphids from sources 3 feet away. The circular infested spots sometimes seen in grain fields are such as would be expected if aphids walked in random directions from a center of infestation. Adults were seen to walk 50 to 75 mm. per minute; small nymphs, 12 mm. per minute. An aphid walking over soil, on seeing an upright object, usually climbs it; it often attempts to feed and may settle down if feeding is satisfactory. When disturbed the tendency is reversed, and the aphid will climb down or even drop from a plant, and will often avoid a plant encountered in walking over soil. After wandering a short time the tendency is again reversed, and the aphid will climb a plant and settle down if there is opportunity. Winged and wingless adults, in the writer's observations, did not respond to sight of a plant over 6 mm. away, and no effect of light on direction of walking was seen. The principal stimulus to leaving seemed to be unsatisfactory nutrition; mechanical disturbance also caused it, and aphids were seen to leave the plants for moist soil when heat became extreme.

Flight seems to require a strong effort, and the winged aphid does not attempt it unless in a good position. Mechanical disturbance may stimulate to flight, especially in warm air. The wind has already been mentioned as a stimulus; the action on the aphid may be direct or through shaking the plants. It has also been noted that flight in still air is not strong, but that it seems to require little effort in a wind; and that the wind governs direction and apparently duration of flight.

Distance covered is difficult to determine. Sanborn (1916) states that *Toxoptera graminum* may spread 50 miles in a day; Webster and Phillips (1912) describing the infestation in 1907, indicate a sudden spread of about 100 miles. *Toxoptera graminum* often occurs in the northern states and Canada in summer, although wintering there has not been found possible. In 1927 migrants appeared suddenly in Minnesota when the nearest known source was about 200 miles away. In 1926 spread must have been much farther. Four winged adults lived without food from 4 to 6 days with the temperature usually 50° and 60° F.; a long flight without feeding would seem possible under cool conditions. Elton (1926) observed live aphids of a Lachnid species flying with the wind to Spitzbergen, the nearest possible source being 800 miles away. Distance covered must depend on the duration of the wind. Migrants of *Toxoptera* are found in new territory well scattered, with no association with lines of travel, or other evidence of commercial spread.

Swarms of flying *Toxoptera* have been noted in connection with several outbreaks. Small numbers fly unsuspected by ordinary observers, but revealed by screen studies as with other aphids. There can be no doubt, however, that the species has a greater tendency than many aphids to develop swarms. This can best be ascribed to the extremely severe injury, which causes nutrition to fail and many winged forms to develop at once; also possibly to a uniformity of response to stimuli, which causes many to rise at once. No evidence of communication has been observed. The swarms do not seem to keep together, but are thinly distributed in new territory. It is not known whether individual winged females may make successive long flights, but meager evidence indicates that they do not. The northern states are usually reached in midsummer, several generations later than states just north of the wintering territory; not about the same time, as would be the case if successive flights by the same individual occurred.

It has been noted that *Toxoptera* was not observed to recognize favorable food-plants at first contact, or to respond to sight of plants more than 6 mm. away. Flying aphids may have better vision, but seem unlikely to discriminate much. These observations seem to stamp migrations as hit-or-miss affairs, often with small chance of success for any given individual. In 1926 swarms developed in Minnesota; a few weeks later the species was hard to find. This reduction cannot be altogether due to the enemies which allowed the swarms to develop, but must be partly due to migration losses. If the aphids were able to seek out food-plants, they would be expected to cluster thickly on the few which are present in late summer; nothing like this occurs. Migrations preserve the species, but must be disastrous to many individuals.

POTENTIAL INCREASE OF POPULATION.

Toxoptera graminum is similar to many aphids in rapidity of potential increase. This is usually held in check by resistance from various sources. Failure or ripening of food-plants, migration losses associated with food scarcity, rain, cold, and insect enemies have been important in Minnesota. The approximate seasonal distribution of these factors is graphed in Fig. 9.

With *Toxoptera* the number of young is not large for an insect, though all are females; but young are born in a comparatively advanced state, and post-embryonic development occupies only a short time. In computing possible increase, it is found that soon after young mature and begin reproducing, the parent's reproduction becomes only a

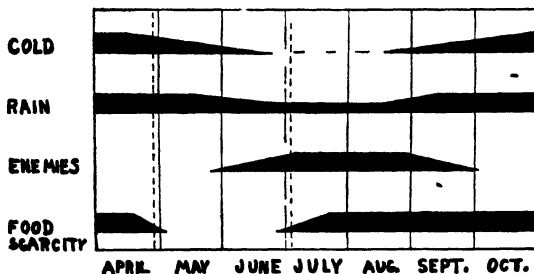


Fig. 9. Seasonal distribution of checks on *Toxoptera* in Minnesota. Dotted lines inclose part of year most favorable for increase. Combined thickness of blocks at any given time gives an idea of total resistance. (Cold makes development impossible, November to March, inclusive.)

small part of the total daily increase. Hence, time required for development, and reproduction rate early in adult life, are most important in rapid increase. Any factor affecting reproduction and development will affect population growth to a degree which is practically a product of the effects on these two. Temperature has a potent influence. Length of day has an influence, but is not so important in the field, as short days occur mostly when temperatures are low. Food is important, as already shown. Any condition producing many winged forms will decrease reproduction and cause scattering.

The period of reproduction is so long that generations overlap at ordinary temperatures, and calculation of possible increase is complicated. The problem is that of a series of overlapping arithmetical progressions; increasing in number, magnitude, and complexity in relations, in geometrical progression. This can readily be seen by calculating the increase under given conditions for two or three generations; adding the young produced by the daily maturing first and second generation aphids to the continuing reproduction of the parent. It seems impossible to find a formula that will be exact and not too complex for practical use. The best method tried so far to obtain an approxima-

tion of possible increase, is to calculate arithmetically until well into the third generation, when proportion of adults becomes nearly stable; then to calculate further, if desired, by using the daily percentage of increase found in the third generation. Table XIX shows possibilities calculated from approximations of figures from Tables III and IV for constant temperatures. Fractional reproduction is calculated by alternation; for example, with $4\frac{1}{4}$ young per day, 5 are counted for the first day, 4 per day for the next 3 days, and so on.

In outdoor rearing with the most favorable conditions, reproduction was seldom over 4 young per day, and development required at least 7 days. With these rates, increase would approach that calculated for 22 to 27° C. The percentage of reproducing adults in the third generation, in hypothetical calculations, is about 12%; in several actual cases in rapidly increasing colonies it was between 10 and 15%.

TABLE XIX.

POSSIBLE INCREASE OF *TOXOPTERA GRAMINUM*, WINGLESS ON OATS,
STARTING WITH ONE YOUNG ADULT.

Temperature, °C.	POPULATION AT				Approximate Percent Daily Increase, Third Generation
	5 Days	10 Days	15 Days	20 Days	
12.....	6	11	16	21	.....
17-17½.....	13	22	77	251	25
20.....	16	45	256	964	35
22-23.....	23	156	807	6,167	50
26-27.....	21	164	962	7,082	50
30.....	20	181	1,202	8,501	50
32.....	9	29	63	319	.....

The increase may also be calculated by number of generations possible, instead of by days. Here the length of development is not a factor, and the measure of increase is the number of young produced before the oldest young mature. This is found to be nearly constant, about 26, over a temperature range from a little over 12° to nearly 30°, except for the favorable temperature about 22°. At the beginning of a generation, young vary from just maturing to newly born; a generation later, the same individuals will vary from some which have reproduced all the time to some just beginning to reproduce; the average will have reproduced about half the period. If 26 young are produced in the minimum time for a generation, the population should increase about 13 times each generation. Examination of several hypothetical series confirms this. The method may be useful in calculating possible increase over a period of varying temperatures.

In several cases one or more females were put into pot-cages containing 4 oat plants of 2 leaves each, and allowed to reproduce unchecked. Reproduction was limited by day-length, as part of this work was done in winter; the theoretical increase was calculated in

each case for reproductive and developmental rates prevailing in the first generation. Production of a few sexual forms interfered very little with the experiments, as they were usually the later-born of the first generation. In most cases the second generation increase held close to the theoretical figure up to a certain point. The plants then

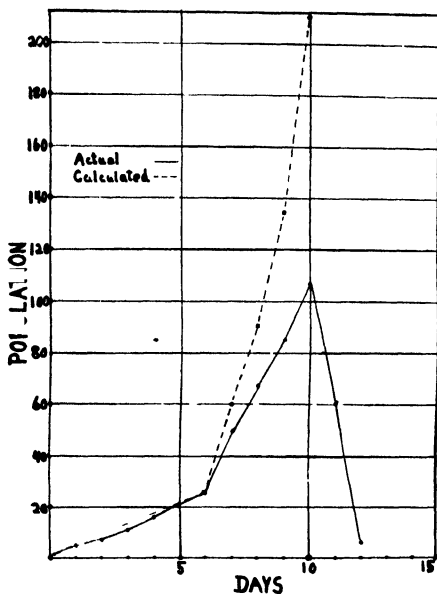


Fig. 10.

Typical case, population increase, *Toxoptera graminum*.

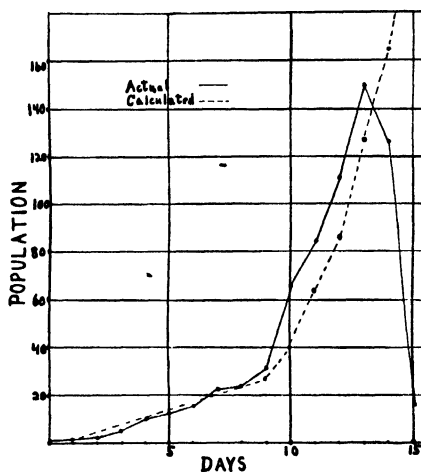


Fig. 11.

invariably failed and died, and there was a sudden drop in aphid population. All aphids left in 2 to 6 days after the peak in numbers. Seven cases with one parent at the start are presented in Table XX; two are selected to graph in Figures 10 and 11.

TABLE XX.

ACTUAL POPULATION INCREASE.

Maximum Number Aphids	Time to Reach Maximum Days	Calculated Number Reached in Same Period	Calculated Time to Reach Actual Maximum, Days
235	18	484	15
150	13	127	13½
107	11	211	9½
262	21	329	20
61	17	73	16½
102	17	128	16+
101	23	265	18+

As the plants were injured, reproduction was restricted and aphids left. Leaving was observed to begin as long as 4 days before the peak in numbers was reached. In several experiments, parallel tests starting with 2 to 16 females were also run. In general, results were similar to those with one parent, but the maximum came earlier with the greater initial numbers and was usually lower. One case is graphed in Figure 12.

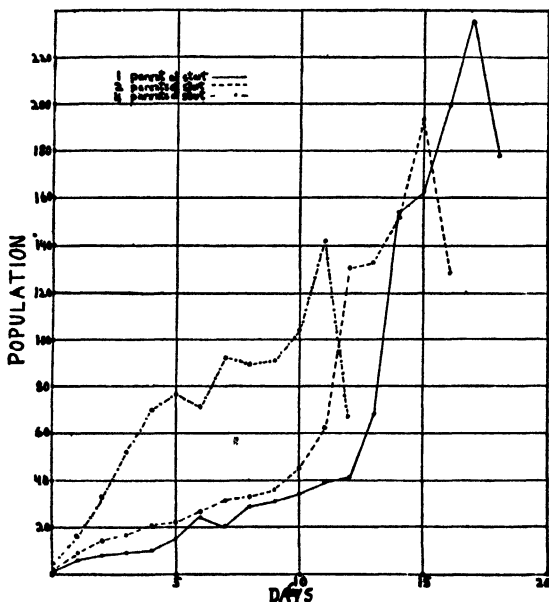


Fig. 12. Typical cases, population increase, *Toxoptera graminum*.

In studying these experiments, it appears that the highest population numbers are reached when many small nymphs are present; plants fail more quickly when large nymphs and adults are numerous. Populations increasing rapidly have been counted in 3 cases; nymphs in the first two instars constituted 60 to 65 per cent, and large nymphs about 25 per cent. As reproduction slows down, the proportion of large nymphs increases; later, as large nymphs and adults leave, the few remaining will be nearly all small nymphs.

Rhopalosiphum prunifolia is very like *Toxoptera* in rapidity of development and reproduction, while *Macrosiphum granarium* is somewhat slower, but generally similar. Their theoretical increase is like that computed for *Toxoptera*. In several cage experiments like those of Table XX, however, these species gave results quite different from those with *Toxoptera*. Two typical cases are graphed in Figures 13 and 14. A rough equilibrium was reached in which aphids leaving (sometimes found dead trying to escape), balanced reproduction.

The food-plants survived indefinitely, though stunted by feeding. With *Toxoptera* death of the plants occurred before aphids leaving could bring about such an equilibrium. This is believed to be because of the characteristic feeding injury of *Toxoptera*, not shared by the other species, and this injury is probably an important factor in the greater economic importance of *Toxoptera*.

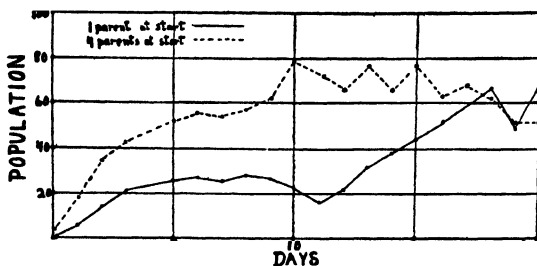


Fig. 13. Typical case, population increase, *Rhopalosiphum prunifoliae*.

In studying field increase, few figures are available. In 1926, in one locality in Minnesota, *Toxoptera graminum* had reached probably several thousand per square foot in places before the middle of June,

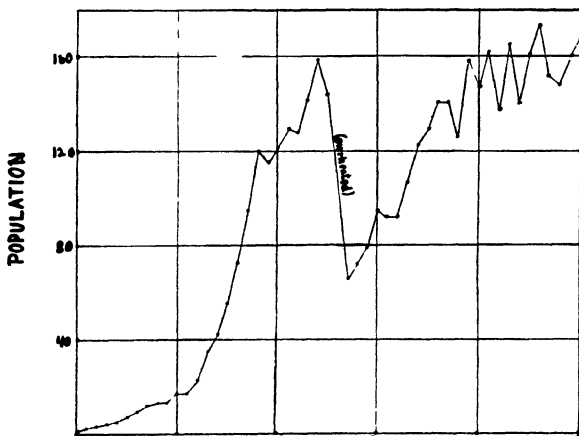


Fig. 14. Population increase, *Macrosiphum granarium*.

on oats which came up late in April. In August, over 4,000 developed in 28 days in an out-door cage from 2 winged adults, at about 70° F. In 1927, a very light but rather uniform infestation of winged *Toxoptera graminum* appeared June 19; in one place 3 were found on 3 square yards. In one field of late wheat, enemies were not abundant and food was favorable. Little rain fell, and the temperature averaged

about 71° F. On July 13 several counts showed 2700 *Toxoptera* per square yard. Even here potential increase for 22° was not realized (Table XIX). *Toxoptera* in the field sometimes rises to great numbers when not checked, destroys the food-plants and decreases in numbers suddenly, as in cage experiments.

Two-leaf plants often support 50 *Toxoptera graminum* before failing; on one-leaf plants about 30 have developed. On one large four-leaf oat plant 154 developed. On rather small three-leaf plants in the outdoor cage mentioned, about 4000 *Toxoptera* developed on 2 square feet. A concentration considerably greater than this was seen in a heavily infested field in 1926. Large leaves may have 50 *Toxoptera* or more, and on large oats in joint 200 large leaves per square foot may occur. It seems probable that on one- or two-leaf oats *Toxoptera* may reach nearly 1000 per square foot before killing the plants; on oats of 3 or more leaves, not jointed, 2000 may be reached; and on large oats in joint, as high as 10,000 per square foot might be attained. In the wheat field mentioned, an infestation of 300 per square foot on large plants was not noticeable except on close inspection. All observations indicate that the peak number is much in excess of that which would be required to kill the plants by continuous feeding.

ENEMIES.

Insect enemies are important in holding economic aphids in check, though by no means the only factors checking them. Nearly every writer on *Toxoptera graminum* has discussed enemies. Few references to insects beneficial to the species occur; ants appear interested in *Toxoptera*, but do not attend it as they do aphids secreting much honey-dew. Parasites of its insect enemies may be considered beneficial to it. Many predators will probably attack *Toxoptera graminum* and other aphids, though they do not concentrate their work as do insects specialized in attacking aphids. Small spiders and large mites have attacked *Toxoptera graminum* in cages, and dragon-flies have been seen around infested grain. McAtee (1913) records observations on birds attacking grain aphids; the numbers eaten would not effectively control heavy infestations. Disease seems to be unimportant with this species; it was not observed even with 100 per cent relative humidity.

In Minnesota, Coccinellids, Syrphids, hymenopterous parasites, Cecidomyiids, and Chrysopids are active in attacking aphids; they are given here in order of importance in connection with *Toxoptera graminum* in 1926 and 1927. Most American workers, dealing with more southern conditions, rank Hymenoptera first; Moore (1914), in Africa, gives Coccinellids high rank.

The test of effectiveness for an enemy of an injurious insect, from man's standpoint, is the power to prevent injury; it involves not only power to reduce the host's numbers, but ability to maintain itself between outbreaks of the host, and to attack it before it is greatly concentrated and doing much injury.

COCCINELLIDS.

Five species of Coccinellids were more or less important in connection with *Toxoptera graminum* in Minnesota: *Coccinella novemnotata* Hbst., *C. transversoguttata* Fald., *Hippodamia convergens* Guer., *M. parenthesis* Say, and *H. tredecimpunctata* L. All frequent low-growing plants. *Adalia bipunctata* L. was numerous; it feeds readily on *Toxoptera*, but its habitat in trees and shrubs does not bring it in contact with grain aphids. Other Coccinellids were observed only in small numbers during this work. Dr. M. H. Hatch, then with the entomology department, assisted in determining these.

The life-cycles of the species are very similar. They differ in size and in the number of aphids consumed. *C. novemnotata* and *C. transversoguttata* are comparatively large, *H. parenthesis* and *H. tredecimpunctata* are smaller, and *H. convergens* is of intermediate size. Some life history data are recorded in Table XXI; they were worked out in the greenhouse in June and July, temperature averaging about 75° F. Rearing was carried on in vials.

TABLE XXI.
DATA ON COCCINELLID LIFE HISTORY.

Species	No. reared	Egg Stage, Days	Larval Instars, Days Average	Total Days	Aphids Eaten by Instars, Average	Total No. Eaten	Pupal Stage, Days
<i>C. 9-notata</i>	10	3-4	3, 2, 2.2, 5.8	13 0	27, 33, 56, 258	374	4 8
<i>C. transversoguttata</i>	5	3	2.4, 2.4, 1.8, 5.6	12 2	15, 29, 48, 253	345	5 2
<i>H. convergens</i>	3	3	3.5, 2.5, 2.3, 7.0	15 3	21, 30, 58, 201	310	4 5

The aphids furnished were *Toxoptera graminum* from stock cages in sizes in proportion as they occurred in growing colonies. (This is true of all feeding tests made with enemies). On single days in the last instar 75 to 100 aphids may be eaten.

Life cycle records for *H. tredecimpunctata* (Cutright, 1924) and *H. parenthesis* (Palmer, 1914) are similar to these. *Megilla maculata* (Tucker, 1918), important in the southwest, and several African Coccinellids (Moore, 1914), also show many similarities. Cutright found that *H. tredecimpunctata* would consume about 120 *Myzus persicae* in larval life.

Tests showed that the females of *C. novemnotata* and *C. transversoguttata* in summer would readily consume 80 or more *Toxoptera* daily, and the males about 50. The female of *H. convergens* ate 50 to 75 and the male 30 to 40. A pair of *H. parenthesis* ate 46 in a day. Cutright records that adults of *H. tredecimpunctata* will average 30 *Myzus persicae* per day.

Table XXII shows some records of oviposition by some reared adults and some collected which appeared to be only beginning oviposition.

TABLE XXII.
OVIPOSITION RECORDS OF COCCINELLIDS.

	Number Females	Date Taken	Average No. Eggs Deposited	Oviposition Period, Days
<i>C. novemnotata</i>	4	June 10 to 17	219	4 to 18
<i>C. novemnotata</i>	2	Reared	200	36
<i>C. transversoguttata</i>	5	June 1 to 20	167	1 to 25
<i>C. transversoguttata</i>	2	Reared	51	15
<i>H. parenthesis</i>	1	July 13	188	47
<i>H. convergens</i>	1	June 21	508	14 (escaped)

Coccinella transversoguttata did not thrive in confinement, and the result may not express its full reproductive power. Cutright records an average of about 400 eggs for *H. tredecimpunctata*. Coccinellid females have lived one to two months in confinement. Adults maturing in late summer may live 11 months in Minnesota, judging from field observations. The pre-oviposition period of reared adults was 11 to 14 days. Palmer (1914) and Cutright (1924) record pre-oviposition

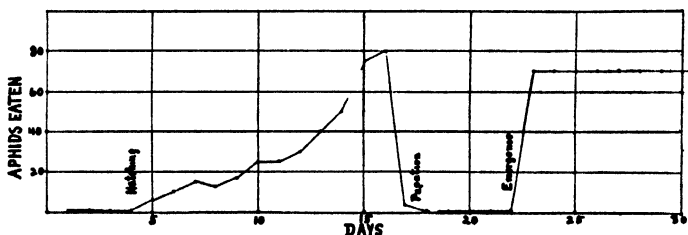


Fig. 15. Life cycle and consumption of Toxoptera, of a typical Coccinellid.

periods of from 1 to 10 days for species treated here. Reared adults of *H. convergens* did not oviposit, though there were evidences of a second generation in the field. Eggs per day usually vary from none to about 60; in one case *H. convergens* produced 130 in a day. All were kept with males and given a plentiful supply of aphids. Vials were used for rearing. Toxoptera was fed when counts were made; on other occasions aphids were collected as convenient. Figure 15 shows graphically life cycle and aphid consumption of a typical Coccinellid.

Life cycles, including pre-oviposition period, thus totaled a little over a month at 75°, which is somewhat higher than Minnesota summer temperatures outdoors. These species should all have time for two generations and a partial third in Minnesota, except *H. convergens*, which started reproduction later in 1927. In the field a second generation seems to develop. Reproduction began late in May, in 1927,

and development was impeded at first by coolness. New adults of the first generation were first noticed early in July, while eggs and small larvæ were seen up to early August. Reproduction was practically stopped in late summer by scarcity of food in both 1926 and 1927, and some time in September it became too cool for reproduction. It is doubtful if a third generation develops in most seasons. *H. convergens* has not been observed in hibernation in Minnesota. Palmer (1917) and others have recorded the adults congregating in large groups, sometimes hundreds, to hibernate. Adults of the other 4 species hibernated scattered in the open fields under grass or any slight shelter. All came through the winter in considerable numbers; the only count made was with *C. novemnotata*, of which 8 were alive and 2 dead in a small area in the spring.

TABLE XXIII.
OVIPOSITION, FEEDING AND TEMPERATURE.

Temperature °C. °F.		Egg Stage, <i>C. 9-notata</i> , Days	Eggs per Day <i>C. 9-notata</i>	TOXOPTERA EATEN PER DAY PER PAIR	
				<i>C. 9-notata</i>	<i>H. convergens</i>
26	78.8	3	14	148	100
23	73.4	.....	8	.....	.....
20	68.0	4	3	123	94
17½	63.5	6	1	72	85
14	57.2	11 (part failed)	0	41	69
10	50.0	all died	0	20	17

It was pointed out by Cutright (1924) and others, and was noted in the field and in experiments, that eggs were not produced without an abundant supply of food. A female of *C. novemnotata*, with an average of 80 aphids a day for 7 days, produced 52 eggs; with 60 aphids a day for 6 days, no eggs. With an abundant supply again given, more eggs were deposited. Larvæ restricted as to food required more time for development than normal, and produced smaller pupæ.

It was early noted that feeding was restricted below 70° F. and nearly stopped at 50° F.; that activity was not general in the spring until temperatures were 70° F. or over, for part of the day. Table XXIII shows some results in the temperature laboratory.

Two larvæ of *C. novemnotata* kept at 17½° and 14° C., required 19 and 30 days, respectively, for the last 2 instars, and consumed 567 and 495 aphids in these instars. The former required 10 days for pupal period; the latter showed no development as a pupa in 12 days, requiring as much time after being removed to 26° as if it had just pupated.

C. novemnotata and *H. convergens* were more numerous in the field than the other species. The reasons for this are not apparent in their reproductive rate, but must be sought in some other factors. Resistance to unfavorable conditions, or ability to find food, may be greater with these species.

The Coccinellids rank high as efficient aphid enemies not only because of the high destructive and reproductive powers shown, but because of hardiness, migratory powers, quickness in producing feeding young, ability to attack small numbers, and ability to maintain their numbers between outbreaks. Adults are present in large numbers early in summer because of their ability to hibernate successfully and live a long time without much food; when food becomes plentiful oviposition begins in a few days. A generation matured late in July, 1926, in eastern Minnesota, feeding largely on the green bug. Food was scarce and reproduction was not observed during the rest of the season. When Toxoptera appeared in June, 1927, many were still present and attack on Toxoptera was seen 11 days after the first migrants appeared. They do not, however, find all aphids, especially small groups. The Coccinellids attacked many common aphids in 1927; the cabbage aphid was fed on only sparingly. According to the literature they attack many suitable insect stages; Forbes (1905) records them as feeding on plant material such as pollen and fungus spores. They are thus able to use a variety of food, but when aphids are abundant will apparently leave everything else. Reproduction has not been observed by the writer in these Coccinellid species except when aphids were plentiful.

A hypothetical calculation, using life history and feeding data worked out, shows that two pairs of *C. novemnotata* could wipe out a colony of 1000 Toxoptera in less than a week in summer, while one pair would keep numbers surprisingly low. It seems unlikely that numbers could be kept in equilibrium, because this implies an aphid consumption equal to aphid increase; when the Coccinellids increased further, aphids would be decreased. A sort of equilibrium can occur in practice when aphids are scarce and Coccinellids not reproducing, enough aphids escaping notice to keep small numbers alive.

Several factors have been observed which detract from their efficiency. They are much reduced in activity below 70° F. In May, 1927 (average about 55°), they showed little activity, while native aphids were multiplying in the field. They seem quite likely to attack other aphid enemies, and often leave a few aphids in sheltered places.

Palmer (1914) and Cutright (1924) name several parasites of different stages; these have not been taken in Minnesota so far. The chief natural control of Coccinellids there seems to be repressed reproduction, larval mortality, and cannibalism, when food is scarce.

SYRPHIDS.

Syrphids were well represented in *Toxoptera graminum* infestations in July, 1926, though not as abundant as Coccinellids. Later a few attacked Toxoptera in the greenhouse. In 1927, they were found in the field where *Toxoptera graminum* attained its greatest numbers. Only 3 species were connected with Toxoptera. *Syrphus americana* Wied. and *Allograpta obliqua* Say were numerous all season and attacked many species of aphids; *Sphaerophoria cylindrica* Say was not generally numerous, but several were reared from larvæ feeding on *Toxoptera*

graminum. The adults were readily determined, by comparison with specimens in the University collection determined by Metcalf and Curran. The larvæ were described by Metcalf (1913). Webster and Phillips (1912) record these 3 species, also Eupodes and Baccha, attacking *Toxoptera graminum* in the southwest; Moore (1914) records a *Xanthogramma* in Africa.

The writer has not been able to obtain eggs in confinement, but has reared in the greenhouse larvæ and a few eggs taken in the field. Three *Syrphus americana* required 8 to 11 days from hatching to pupariation, consuming 440 to 472 Toxoptera; five puparia required 7 to 9 days to yield the adult. Two very small larvæ of *Allograpta* required 5 days each to complete development and ate 242 and 270 Toxoptera; 10 puparia required 6 to 11 days, averaging 8.3 days to yield the adults. Three *Sphaerophoria* spent 5 to 6 days as puparia.

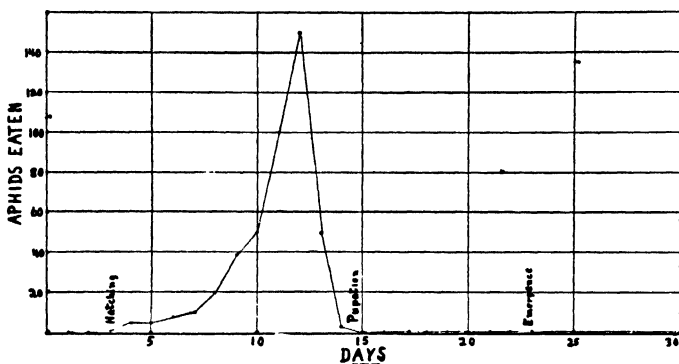


Fig. 16. Life cycle and consumption of Toxoptera, of a typical Syrphid.

Some adults were dissected. One *Syrphus* had 66 eggs. Six *Allograpta* had from 16 to 58; three of these had from 54 to 58, indicating a maximum near 60. One new adult of *Allograpta* had only a few eggs, small and indistinct; this may indicate a pre-oviposition period of adult life in which eggs develop. Adults did not live over 7 days in confinement, even when fed sweetened water. The larvæ reared ate 10 aphids a day, or less, the first few days, then fed and grew rapidly; three-fourths of the total aphid consumption was eaten in 3 days, as high as 150 aphids in a day by *Syrphus*. The aphids are sucked dry, the skins being left. Figure 16 shows graphically life and aphid consumption of a typical Syrphid.

Metcalf (1913, 1916) records egg stages of $2\frac{1}{2}$ to $3\frac{1}{2}$ days, and larval stages of 8 to 14 days for these species. Adults deposited as high as nearly 100 eggs. He found larval life might be prolonged if food was scarce.

Adult Syrphids hover over plants and seem to examine them carefully. Eggs are usually found on leaves well infested with aphids, and only one or a few on a leaf. The adults seem to require warmth and

sunshine for activity. A decrease in numbers of larvæ, presumably due to less oviposition, followed a cool, cloudy period in August; after a sunny period numbers again increased. Larvæ are not so sensitive to coolness; one of *S. americana*, at the height of its feeding power, ate 94 Tioxoptera in a day at 14° C., 35 at 10°.

The first larva occurred early in June, 1927, in a sunny location; larvæ became common late in June. Adults were most abundant in early July and early August; larvæ in late June, late July, and early September. July 25, about half the aphid-infested cabbage leaves in one garden bore Syrphid larvæ; August 31, about one-third; September 8, following two weeks of sunny weather, about two-thirds. Adults were not reared after September 10 at outdoor temperatures; only puparia were present in October. Syrphid larvæ were found late in summer feeding on the cabbage aphid, which was avoided by Coccinellids. Metcalf (1913) believes the puparium to be the hibernating stage.

Of 26 larvæ collected in July and August to rear, 9 yielded parasites. *Bassus laetatorius* Fab. was the principal parasite, occurring one in a host, and emerging 11 to 17 days after the host puparium was formed. One specimen of *B. frontalis* Cress. was reared, from a larva also yielding a *B. laetatorius*. A third species, *Syrphoctonus maculifrons* Cress., was reared from several puparia. Two larvæ yielded small chalcids, 8 or 9 to a host, determined as *Pachyneuron allograptae* Ashm.

Data given will indicate the power of controlling aphids. The Syrphids do not destroy parasitized aphids; they are able to penetrate pseudogalls and other inclosed places. They feed on a large number of aphid species. Adults seem to show considerable discrimination in finding oviposition places, so that large aphid infestations soon have eggs among them; larvæ will be present and growing within a week later. Hibernation must be fairly successful, as the first generation is numerous.

Only the larvæ feed on aphids, and most of the feeding is during a brief period; however, variations in emergence and adult longevity may give a fairly continuous supply of eggs. Syrphids are often considerably parasitized. In Minnesota in 1927 parasitism was not sufficient to check their attack on aphids; but parasitism has checked them in localities of longer seasons (Metcalf 1913, Moore 1914). The Syrphids appeared rather late in the season, perhaps because coolness prevented adult activity. Their most serious weakness in aphid control, however, is the fact that they seem to attack only where aphids are already numerous. Adults seem to select crowded colonies for oviposition. The larvæ can hardly travel over soil, and probably need plenty of food close at hand; the rather helpless newly hatched larva may require close proximity to food to succeed. Plants with large leaves, such as cabbage, are best adapted for them; oats can hardly support enough aphids for Syrphid larvæ unless crowded.

On the whole, the Syrphids were a definite check on all aphids observed in Minnesota, but were less efficient than the Coccinellids as enemies of most species, mainly because they required a high host concentration before beginning work. They have appeared among

Toxoptera colonies in every case in which the aphids became very numerous, but have not been seen attacking small infestations.

HYMENOPTEROUS PARASITES.

Webster and Phillips (1912) list a number of parasites reared from *Toxoptera graminum*, both ichneumonoid and chalcidoid; also several chalcidoid and cynipoid secondary parasites. Webster (1914) adds a chalcidoid parasite; Moore (1914) adds another ichneumonoid parasite of considerable efficiency, and notes that *Diaretus rapæ* Curt. will attack *Toxoptera* sparingly when near the cabbage aphid, its regular host. The currant aphid parasite, *Aphidius ribis* Halid.; and also a species of *Monoctonus*; may here be added to the list. *Lysiphlebus* (*Aphidius*) *testaceipes* Cresson, an ichneumonoid parasite of the subfamily Aphidiinae, is recorded in the literature as showing considerable power of control. *Aphidius*, *Monoctonus*, and *Diaretus* are also genera of this subfamily.

Hymenopterous parasites have not been of importance in Minnesota in 1926 and 1927. A few *Lysiphlebus* were reared from *Toxoptera* in midsummer, 1926. Late in the season *Toxoptera* was scarce in the field and no parasites were found. In the greenhouse a few parasitized *Toxoptera* were seen in late summer, but the parasitism failed to increase. In 1927, *Toxoptera graminum* on open oat beds in the greenhouse showed a slight degree of parasitism late in June. One parasite reared proved to be *Aphidius ribis* Halid., which was attacking the currant aphid outdoors at the same time, and might readily have come in through the ventilators. *Toxoptera graminum* appeared in the field late in June, and by mid-July increased to considerable numbers in spots. In one well infested field, July 12, 0.5 per cent parasitism was shown; in a smaller infestation 5 out of 35 were parasitized, or 14.3 per cent. These parasites, on rearing, proved to be *Lysiphlebus testaceipes*. The rest of the summer *Toxoptera* was held down by predators, and no parasites were seen in the field. In the greenhouse in August, a few parasites attacked *Toxoptera*, but failed to increase as before. Some reared included *Aphidius ribis* Halid., *Monoctonus* sp., *Aphelinus semiflavus* Howard and one specimen of *Pachyneuron siphonophoræ* Ashm. The last named is probably a secondary parasite. To sum up, *Lysiphlebus* appeared only in small numbers, and after the season and the *Toxoptera* infestation were well advanced; the infestation decreased from other causes before *Lysiphlebus* had a chance to increase, and the parasite disappeared. Other parasites attacked *Toxoptera*, but did not increase on it, apparently failing to thrive.

Some notes may be added on parasitic control of other species of aphids. Most species observed were not parasitized much in the field in 1927. The currant aphid was considerably parasitized by *Aphidius ribis* Halid., the cabbage aphid by *Diaretus rapæ* Curt, in June and later. Both these parasites were themselves checked by secondary chalcidoid and cynipoid parasites in July and later. *Macrosiphum*

granarium Kirby, present only in small numbers, was lightly parasitized by *Aphidius nigripes* Ashm; it has been highly parasitized in Minnesota when numerous (Washburn, 1908-A).

Parasites of aphids and Syrphids were determined from works by Ashmead (1900, 1903, 1904); Gahan (1911); Howard (1908); Hartley (1922); Girault (1917); Viereck (1916). Determinations were kindly confirmed by specialists of the U. S. Bureau of Entomology.

Records of effective control of Toxoptera by *Lysiphlebus* farther south are many and detailed. Webster and Phillips (1912) give many important facts on the life history of the parasite, showing that it may increase several times as fast as its host at moderate temperatures, but that it is checked by coolness, and inactive below about 56° F. How percentage of parasitism varies with density of host population is an interesting question; it is to be hoped that such records will be made in the future. The writer in Minnesota and Tucker (1918) in Texas found that the parasite practically disappeared when its host became scarce. Other aphid species have been recorded as hosts; these probably carry the parasite over when Toxoptera is scarce. The efficiency of *Lysiphlebus* in control of Toxoptera will be less than generally supposed if it proves that the parasite requires a high host concentration before beginning work.

Webster and Phillips describe successful hibernation of *Lysiphlebus*, and activity as early as March or April, in Oklahoma; accounts of numbers developing show that it must be generally present at the opening of the season. In Minnesota it was much slower in beginning work, even considering the later spring there; it has appeared in small numbers only after Toxoptera has been present and temperatures favorable for some weeks, and after related parasites have been active for some time. It is evidently absent or scarce at the beginning of the season in Minnesota, and probably fails to winter or winters only in restricted environments.

CECIDOMYIIDÆ.

Several writers have noted small Cecidomyiid larvæ attacking *Toxoptera graminum*. The writer found and reared two attacking Toxoptera in the greenhouse in late summer of 1926. These larvæ were present in infestations of various aphids in 1927, from July to early September, though they were not found attacking *Toxoptera graminum*. They feed readily on Toxoptera, sucking out their juices. Some have been determined by the use of Felt's treatise on this section of the family (1917), as *Aphidoletes meridionalis* Felt. Davis (1916) found adults to deposit over 100 eggs, and each larva to consume several dozen aphids, and to require about 3 weeks in development in summer. They have not been observed to constitute a major check to any aphid species; factors limiting their efficiency are not yet discovered, except that they evidently multiply only in warm weather. They may be considered a minor check to aphids which become considerably concentrated.

CHRYSIDÆ.

A few eggs and larvæ of Chrysopids occurred in fields infested with *Toxoptera graminum* in July in both 1926 and 1927; in September, 1926, a larva penetrated a rearing cage. The only adults taken were determined from Bank's key (1903) as *Chrysopa plorabunda*; *C. oculata* also occurs in Minnesota. Activity has not been noted in Minnesota before July, too late for importance in grain aphid control. The ability of the larvæ to move actively in search of food, and to attack scattered aphids, is of value in late summer aphid control. Smith (1902) states that *C. oculata* may consume 170 aphids in a larval life of 19 days.

BIOLOGICAL CONTROL AS A WHOLE IN MINNESOTA.

Regularly occurring aphid species hatched late in April, 1927, and were able to increase slowly without being attacked by enemies for about a month. In some cases considerable abundance was reached. Late in May and during June, enemies began to work, and migrants to develop and leave. These factors caused declines in June, in spite of more rapid reproduction with warmer weather. Colonies on spring food-plants disappeared in many cases in June. Colonies on summer food-plants appeared in June and increased in July. In most cases these were held well in check by enemies. Coccinellids attacked every species observed but the cabbage aphid; dipterous larvæ, those which formed large colonies; and Hymenoptera, certain species evidently adapted to the parasites.

In studying the 1926 outbreak of *Toxoptera graminum* it is found that in the region first noticed as infested, great numbers were present before the middle of June (Ruggles and Wadley, 1927). This corresponds somewhat to the development of native aphids on spring food-plants; natural enemies would not be expected to check the aphids much. In eastern Minnesota infestation evidently came later; late sown grain was most seriously affected, and large numbers were reached in late June or in July. This is similar to development of native aphids on summer food-plants, and some biological control should occur. Late in July, counts showed 3 to 18 Coccinellids per square yard, mostly large larvæ and pupæ, in infested fields; other enemies were much less numerous. These larvæ must have been the progeny of adults occurring not over one to 5 or 10 square yards, and must have consumed from 1000 to 6000 *Toxoptera* per square yard in developing. This number is not sufficient to control a severe outbreak; large swarms of migrants developed in some cases. Lack of biological control seemed to be due to small numbers of enemies at the start, so that migrants gave rise to groups of aphids without interference, in many cases.

In 1927, few large infestations of *Toxoptera* developed. The first migrants came late in June; food-plants became mature soon after this and predators were active. In one late-sown field, counts showed a concentration of 2700 per square yard, approaching injurious numbers.

At this point the plants were reaching an unfavorable stage for Toxoptera. Enemies present included, in areas counted, 5 larval and 7 adult Coccinellids, and 4 Syrphid larvæ, per square yard; and Hymenoptera producing 0.5 per cent parasitism. The Coccinellid adults were just beginning to oviposit, hence were probably recent arrivals. The Coccinellid larvæ were from eggs deposited a week or more before. The predaceous larvæ had probably eaten nearly 1000 aphids per square yard in developing. All predators present could devour about 1000 aphids per square yard per day. As Toxoptera can reproduce at a rate approaching 50% per day in warm weather, numbers would have remained nearly balanced if it had reproduced normally, until more predators developed. On the other hand, if reproduction ceased altogether, due to approaching maturity of the plants, the predators present could wipe out the infestation in 3 days. Actually, all were gone in 8 days; few migrants left the plants.

It is evident that little can be expected from Hymenoptera in controlling Toxoptera in Minnesota; but that predators, especially Coccinellids, will be of considerable value. It is also evident that they must be present in some numbers early in the season to check injury, and that such numbers will depend on food supply the previous season. Infestations of various aphids will keep alive biological resistance which will be of value against injurious aphids. In 1926 they were not able to control *Toxoptera graminum*, even in many eastern Minnesota fields where infestation developed in midsummer. In 1927 they were able to control it, probably because of numbers built up the previous year.

PART II.

FACTORS AFFECTING DISTRIBUTION, ESPECIALLY AS TO NORTHERN OUTBREAKS.

The distribution and importance of *Toxoptera graminum* is obviously much influenced by climate, and by factors such as abundance of food-plants which are themselves affected by climate. Winter cold seems important in connection with distribution, as does rainfall; summer weather and conditions accompanying it have profound effects on numbers of Toxoptera.

DISTRIBUTION RECORDS.

From a study of the literature Toxoptera may be said in general to be important only in the lower temperate latitudes where grain growing is widespread; in higher latitudes it is found temporarily or in small numbers, in the tropics only at high altitudes. The grain areas of South America and Australia, though in lower temperate latitudes, have not been reported as infested.

In America the species has been recorded from most of the states and several Canadian provinces, but seems to occur temporarily or

persist only in small numbers in the north, and to be established in the south. Webster and Phillips (1912) give reasons for believing the species introduced in America, and note the first occurrence in Virginia in 1882, and injury as far west as Texas in 1890. These and other writers (Morrill, 1913; Bentley, 1914; Kelly, 1917; Garman, 1926; U. S. Entomologists' Reports; Insect Pest Survey) give an economic history of the species.

From 1890 to 1927, more or less injury has been done in 16 years; references in other years seem to indicate merely the presence of the species. Injury has been estimated in millions, and has been of major importance to the areas concerned, in 5 years; in 1890 in parts of Texas, Missouri and Illinois; in 1901 northern Texas; in 1907 in Texas, Oklahoma and Kansas; in 1916 in Oklahoma, Kansas and New Mexico; and in 1926 in parts of Minnesota. Infestation was wide spread in some of these years, but the areas named were the ones badly damaged. Injury has been reported several times in the Carolinas and neighboring states, and was rather severe there in 1907.

This study reveals Oklahoma and northern Texas as most frequently injured, a large part of the country east of the Rockies south of 40° latitude as occasionally damaged, and only infrequent injury in other parts of the country.

TABLE XXIV.

TERRITORIAL DISTRIBUTION OF RECORDED INJURY, 1890 TO 1927.

Area	Years of Injury	Years of Major Losses in Parts
N. Texas to Kansas.....	12	4
States west of this longitude.....	4	1
States east of this longitude.....	9	2
Arizona to Carolinas.....	14	4
States in latitude of Missouri.....	7	1
States north of this	2	1
Gulf Coast (S. Texas to Georgia).....	1	0

INFLUENCE OF RAINFALL ON DISTRIBUTION.

Several writers have shown association of outbreaks of *Toxoptera* in the region most often infested, with preceding summer rainfall which maintained food-plants, with mild winters, and with late spring. There is also an association of injury with light rainfall, which may be briefly studied here, since it has received little previous attention.

Reduction of numbers of *Toxoptera graminum* by rain has been described. It is obvious that frequent rains will check, but will not eliminate the species; and that if it is generally distributed, a few weeks with little rain will suffice to build up injurious numbers. It is also plain that increase to injurious numbers will take place only when temperatures are high enough for development and crops affected are

immature. This points to the period of injurious increase as late fall, winter and early spring in the south, spring months in the middle states, and late spring and early summer as far north as Minnesota. A third consideration is that the species cannot thrive without sufficient rain to maintain some food-plants through the year. These facts give a basis for examining the influence of rainfall on distribution.

It has been shown that Texas and Oklahoma have had more records of injury than the wide expanse of states to the east, and many more than states farther west. The climate in the states west of Oklahoma is very dry and grain growing is limited. Toxoptera probably has difficulty in maintaining itself through the year because of a precarious food supply associated with very dry conditions. The rainfall of states in the longitude of Oklahoma is sufficient for grain farming, and is heaviest in late spring and summer, and light in fall and winter. Farther east rainfall is somewhat heavier, especially in winter and spring, the time injurious increase must occur in this latitude.

Northern Texas and Oklahoma may be compared with Tennessee and the Carolinas, where Toxoptera has often been reported, but where injury has been less frequent and severe. In the western area, representative weather stations, from November to April, inclusive, average $1\frac{1}{2}$ to $2\frac{1}{2}$ inches of rainfall per month, and from 4 to 7 rainy days per month. In eastern area averages are 3 to $4\frac{1}{2}$ inches and 8 to 12 rainy days, respectively. It seems likely the frequent rains in the east are a factor in repressing Toxoptera; this may be further tested by a study of weather of outbreak years.

It is found that in Texas, Oklahoma and Kansas winter and spring rainfall in the four serious outbreak years has been either about normal or below normal; never much above normal. In the regions east of this longitude, great abundance has usually been associated with deficient rainfall. The 1890 outbreak was serious in parts of Missouri and Illinois near St. Louis, in May and June. It was accompanied by variable and generally deficient rainfall over this area in these months, though winter and early spring had been rainy. The conditions were similar in the 1926 outbreak in Minnesota and neighboring states, as will be more fully discussed later. The 1907 outbreak in Virginia and the Carolinas followed a winter of marked deficiency in moisture, with some very dry months. The less marked outbreaks in South Carolina in 1913, and in South Carolina and northern Georgia in 1914, are found to be associated with some deficiency in winter rainfall; in the former year Luginbill (1914) speaks of March rains helping to end the outbreak. A number of complaints in Tennessee in the spring of 1913 were associated with a dry April. The less important occurrences are harder to relate to weather, especially as the exact localities infested are often not recorded.

In 1915 the green bug was widely distributed in fall and early winter over Oklahoma, southern Kansas, northern Texas and northeastern New Mexico, (Webster, 1916). However, very heavy rains fell in January and again in April, in northern Texas and southern Oklahoma, and damage seems not to have developed there. In southern Kansas,

northern Oklahoma, and New Mexico it remained dry, and injury was severe (Kelly, 1917).

It is concluded that the green bug is most often injurious in a region having rainfall that is sufficient for grain production, but is rather light, with comparatively long dry spells, during the period of injurious increase. In rainier areas injury is less frequent and is usually associated with rainfall shortage. It seems likely that this relation may be

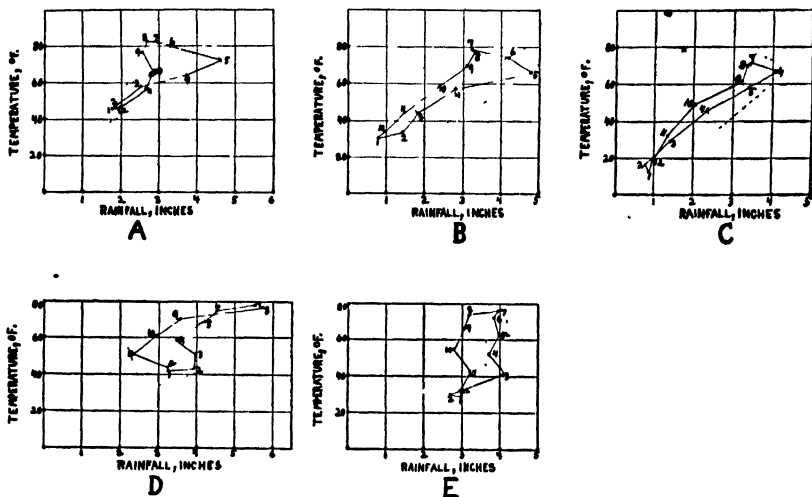


Fig. 17. Climographs of monthly means, localities of interest with respect to *Toxoptera graminum*. Broken lines inclose parts of year in which injurious increase occurs.

- A. Fort Worth Texas. Winter temperatures and rainfall favorable.
- B. Wichita, Kansas. Winter temperatures less favorable, rainfall favorable.
- C. St. Paul, Minnesota. Winter temperatures very unfavorable, spring rainfall not very favorable.
- D. Raleigh, North Carolina. Winter temperatures favorable, rainfall less favorable.
- E. Indianapolis, Indiana. Neither winter temperatures nor rainfall very favorable.

ascribed to the known action of rain in reducing numbers. The foreign distribution of recorded injury (Hungary, Italy, southern Russia, South Africa) agrees in general with this conclusion. Minnesota is not particularly favorable from the standpoint of rainfall; injurious increase must take place in May and June, which normally have from 3 to 5 inches of rain and 8 to 11 rainy days, at most weather stations.

Climographs of several representative localities, of interest with respect to *Toxoptera*, are shown in figure 17.

EFFECT OF SUMMER CONDITIONS.

The problem of surviving the summer is a serious one for this species. A great reduction in numbers takes place; it cannot be explained by direct effects of heat in the northern states. The most apparent causes are food scarcity and associated migration losses, as grain crops mature, and increased activity of enemies. In the south these conditions may be expected to be worse and more prolonged, with added injurious effects of high temperatures; summer conditions and scarcity of grain crops probably limit distribution southward. Food supply in summer seems to be a critical point; enemies will not exterminate the green bug in the presence of abundant food, judging from observations made in this work.

In Minnesota in 1926 and 1927, *Toxoptera* persisted in very small numbers through late summer and fall, on volunteer plants of oats and wheat. They were most readily found in thick growths around elevators, which afforded a constant food supply and some shelter from Coccinellids, but a few were observed in the open.

Nothing has been found to indicate that migrants from the north restock the south in the fall, though we have considerable evidence for the reverse happening in the spring. The small and scattered colonies found in the north in the fall would not give rise to many migrants, such as come from southern grain fields in the spring. *Toxoptera* is sometimes more abundant in late fall in southern states than in territory just north of them, according to Kelly (1917) and the writer's observations, which would not be expected if the sources of infestation were northward. It seems likely that aphids found in the south in winter are descendants of some which survived the summer in that region; and that green bugs which succeed in passing the summer there are the source of much of the injury for the whole country. The question of summer survival in the south is thus of considerable importance; our information upon it is still quite limited.

Though the species has not often been followed through the summer in middle and southern states, its success in going through is attested by numerous records of its presence in fall and winter. Volunteer grain is undoubtedly important in survival there, as in Minnesota; Webster and Phillips (1912) record bluegrass as a summer food resource. Orchard grass occurs in the border states, and Johnson grass farther south; both have been recorded as rather acceptable food. Johnson grass is of especial interest, because of Moore's account (1914) of its importance as a food-plant in South African summers, and because of its flourishing growth under hot, dry conditions. In the area from North Texas to Kansas, most frequently injured, summer conditions are very severe and food supply must be especially critical. Some of the greatest outbreaks have been associated with abundance of volunteer grain the summer and fall before.

Several workers have shown association of injury with late, cool springs; these may be looked upon as seasons in which unfavorable summer conditions are delayed, giving more time for increase to injurious

numbers. Glenn (1909) and Kelly (1917) have shown association of outbreaks with preceding rainy summers, which would maintain food-plants and make summer survival easier.

LIMITATIONS DUE TO WINTER COLD.

Toxoptera graminum is not limited in northern distribution by summer coolness, as suggested by Merriam (1895); the species thrives at summer temperatures in the northern grain-growing regions. It is rather limited by winter cold, as indicated by Sanderson (1908). *Toxoptera* may appear in spring or summer in spite of winter cold, in three ways. Active aphids or eggs may winter, or migrants from more southern regions may come in.

WINTER EGGS.

Several factors limit the economic status of *Toxoptera* wintering as eggs. The egg-producing forms may not develop; eggs when produced may not winter successfully; migrants produced by aphids hatching from winter eggs may not reach the grain fields in time to be injurious.

In this work sexual forms have developed after 2 generations under day-length somewhat shorter than 12 hours and temperatures averaging 70° F. or less, and their development has been limited by cold. In both 1926 and 1927 sexual forms began to mature in the greenhouse about October 20, among progeny of parents born after September 25. Day-length evidently became favorable the last week in September of each year. In the outdoor insectary each year only one generation was born and matured, after September 25 and before cold weather; some brought into the greenhouse in November, 1927, produced sexes in the next generation. No sexes were found in small groups observed in the field. In 1926, in a protected outdoor cage, no mature sexes were found in frequent observations, through the fall; but one oviparous female, nearly mature, was seen November 13, just before permanent freezing weather. In 1907, experience in Minnesota was similar to the writer's (Washburn, 1908-A), but some eggs were found in a river gorge the next spring (Washburn, 1908-B). This is a peculiar location; deep gulches may shorten the day by shadows, and give some protection against cold. No *Toxoptera* were found in such places in 1927.

It is evident that general production of sexual forms of *Toxoptera* in the field in Minnesota does not occur because of cold stopping development. Such production would require two generations maturing after September. October is nearly always too cold for this to occur, and November allows practically no development, even in the milder falls. In Indiana sexual forms have often occurred (Webster, 1892; Webster and Phillips); the fall is milder than in Minnesota and days shorten nearly as fast. In Kansas, with similar day-length and temperature, but more clear weather than Indiana, sexes were not found in the field in 1907 or 1915, but were seen in 1908 (Kelly). In the south days shorten more slowly, but temperatures even in winter allow some development; it would seem that sexes might occur late in the fall.

They have been seen in the field in Tennessee in 1908 (Webster and Phillips), and reared in South Carolina (Luginbill and Beyer) and, in Texas (Tucker). Published records are too few to furnish a basis for comparison; it seems, however, that these forms occur more commonly in the southern and middle states than in Minnesota, which would be expected from day-length and temperature relations.

As to successful wintering of eggs, data already cited indicate that the eggs are hardly able to withstand Minnesota winters, but that some may come through. It seems that eggs winter successfully in Indiana.

Late development of migrants is a factor limiting economic importance of *Toxoptera* wintering in the egg. The first generation from the egg, the stem-mothers, develop slowly because of coolness and are wingless. Their progeny must also mature before there is a possibility of migrants leaving winter food-plants. In records of rearing in Indiana, cited by Webster and Phillips (1912), a representative stem-mother hatched March 28, and matured April 18; her oldest progeny matured May 9. In Minnesota most native aphids hatch late in April, and migrants begin to appear about June 1. It seems unlikely that *Toxoptera graminum* wintering as eggs could reach spring grain fields there much before June (see Table II) which is too late to do much damage. It is evident that *Toxoptera* hatching from winter eggs will hardly be able to injure spring grain, unless very backward weather holds crops back after warm weather has enabled migrants to develop, or unless very late fields occur. Webster and Phillips express doubt as to the importance of such wintering. All important outbreaks on which data are available can be connected with live aphids wintering, or migrants coming in.

It is observed that many aphid species common in Minnesota produce the sexes and eggs in advance of cold weather, and hatch in the spring, quite regularly, in contrast to *Toxoptera graminum*. By day-length relations differing from those of *Toxoptera*, or some other factors, they are definitely adapted to persist in the north.

SURVIVAL OF ACTIVE APHIDS.

Observations on effects of cold on *Toxoptera graminum* have been recorded. They indicate that the aphids can survive cold seasons where minima are somewhat above 0° F. and temperatures are often high enough to permit some development. This survival cannot be called hibernation, but is rather a period of slow development, interrupted by inactivity caused by cold. Aphids found in the spring will probably not be the ones present the fall before, but their descendants, as adults have not been observed to live long enough to pass a winter. With protection, more cold may be withstood; the effect of snow has been mentioned, and the protection of clumps of volunteer grain may approach that recorded by Headlee and McColloch (1913) for prairie grass. Cold prolonged enough to force inactivity for several weeks, however, will be fatal even if not very severe.

Many references are found to survival in the south, especially in the Carolinas, Tennessee, Oklahoma, and Texas. In these states the

normal mean temperatures in winter months are nearly 40° F., or higher, and minima seldom approach 0° F. Data recorded by Webster and Phillips (1912), Hunter (1909), Kelly (1917), and Howard (1921) show that survival may also occur as far north as Kansas and Indiana, at least in the milder winters, but this seems to be less frequent. No records are found of survival in states farther north. Records examined do not show widespread survival of months averaging as low as 30° F., and considerable reduction in numbers usually accompanied months below 35° F.

Winter survival by active aphids is of great economic importance. From Table XXIV it will be seen that by far the most frequent injury has been noted in the territory where survival is common. During the milder winters not only survival, but considerable increase and injury may occur; Webster and Phillips, and Glenn (1909) have shown an association of injury with mild winters. Winter oats and wheat, and volunteer grain, are affected. Spring sown grain is reached by migration later. In areas just north of this, where survival is less common, some recorded cases of injury can be ascribed to *Toxoptera* surviving mild winters. This is true of injury in eastern Kansas in 1908 and 1921. The injury in southern Kansas in 1916 seemed to be worst where aphids survived locally. In this year injury occurred in spite of a rather cold winter, because of large numbers in the fall, and a spring favorable to survivors. In Missouri and Illinois in 1890, the preceding winter was mild enough to have permitted survival; *Toxoptera* was observed to survive in Indiana, (Webster and Phillips). However, in these latter two cases some indications of infestation by migrants exist. Aphids surviving in the south are a source of infestation by migration for areas farther north.

No indication of possibility of winter survival of this kind in Minnesota can be found. The winter months normally average between 10° and 20° F., and temperatures forcing inactivity may last for months. Minima are often —20° F. or lower, but these seem less important, because of snow protection, than the protracted cold. Records in the literature, field observations, and extensive laboratory experiments do not show sufficient resistance to cold; no records of survival even as far north as Nebraska and Iowa have been found. In 1926, in a fall and early winter not unusually cold at St. Paul, unprotected *Toxoptera* failed to live through November, and some considerably protected did not survive December outdoors; some observed in the field failed to live through the winter. From all standpoints survival seems impossible, in even the mildest Minnesota winter.

Climographs of several localities of interest with respect to winter survival of *Toxoptera* are shown in Figure 17.

SPRING OR SUMMER MIGRATION TO NORTHERN STATES.

The manner of migration has been discussed. Factors affecting its economic importance may be studied briefly. Records in the literature show that winged forms may leave wintering places in the south as early as March in some years. They probably leave as late as May,

or until grain in the south is nearly mature. They are dependent on the wind; if they drift north, they will reach areas where the season is not so far advanced as in the places they left, and where food supply may be more favorable. If they drift in other directions they will

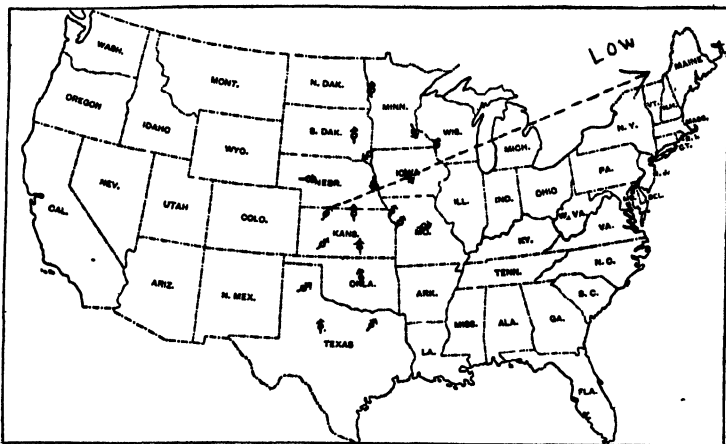


Fig. 18. Wind direction April 26, 1926. Copied from daily weather map. U. S. Weather Bureau.

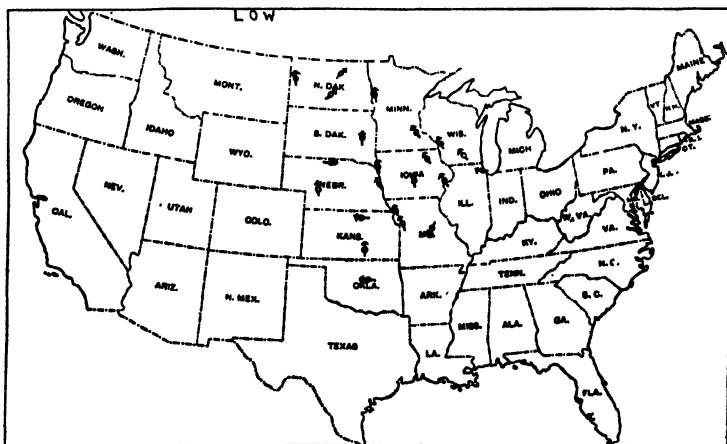


Fig. 19. Wind conditions, June 18, 1927. Copied from daily weather map.

reach areas with the season as far advanced as the one they left. In the territory most infested, the wind is often from the south in spring, and a south wind is probably warmer and more stimulating to flight than one from another direction.

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Wind mileage at different stations for the two most favorable periods in 1926 is shown in Figures 20 and 21; this was kindly furnished by Weather Bureau officials.

Field notes on migration into Minnesota may be mentioned here. In 1927, a careful search was made by the writer in all sorts of favorable locations in Minnesota, but *Toxoptera graminum* could not be found in the spring. On June 19 a few winged forms were found at St. Paul; in the next few days migrants and small young were found at several points around St. Paul, at Winona and at Owatonna. In each place the infestation was of about the same date and of a similar thin distribution. In a plat of late oats the smallness of plants permitted a count; 3 migrants were found on 3 square yards. About the same time

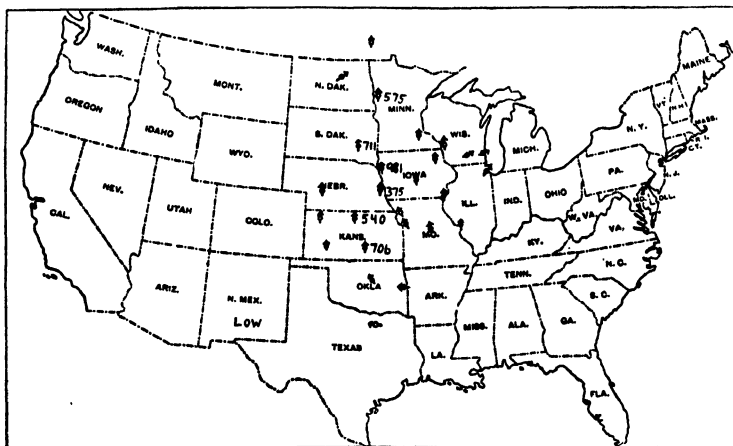


Fig. 20. Wind conditions, April 20, 1926. A representation of conditions both April 19 and 20, with total wind mileage for period shown by each station in probable path of infestation. From Weather Bureau records.

specimens (including nymphs) of *Toxoptera graminum* were received from southeastern Iowa, showing that they were breeding there. The wind June 18 and 19 was suitable to distribute aphids from this region to Minnesota. These facts strongly indicate migration. *Toxoptera* was found breeding in northwestern Minnesota later in the summer.

In 1925, a winged specimen of *Toxoptera graminum* was taken on a sticky screen in July, at St. Paul, and preserved, by Mr. R. E. Wall. In 1926, an outbreak of *Toxoptera* occurred in Minnesota, the source probably being early migration; this will be treated more fully under the next heading. In 1928, as the work was being concluded, a few migrants of *Toxoptera* were found early in May at St. Paul, after several days of south wind. No local source for the migration could be found. Numbers were very small and distribution was not general; most of the small grain was not yet up, owing to unusual cold and snow in April and backwardness of farm work; and a serious infestation did not

Migration has sometimes, but not often, been the source of serious injury; the majority of outbreaks have occurred where the species survives the winter. In 1907, Webster and Phillips leave no doubt that severe injury was done in Kansas by an infestation established by migrants; this was associated with warm weather in early spring and early migration, and with backward weather in late spring, giving time for increase. In 1890 near St. Louis, and in 1916 in Kansas, spring oats were most injured; these must be reached by at least a short migration. In 1916 injury seemed to extend north of the region of general survival. Some injury to oats caused by migrants occurred in Central Kansas in 1922. In 1926 in Minnesota injury seems to be associated with unusually early arrival of migrants. Information given by Prof. C. J. Drake as to conditions in northern Iowa, and observations by the writer in Minnesota, in 1927, causes suspicion that very late-sown spring wheat and oats are slightly injured in the north more often than is generally realized.

PROBABLE SOURCES AND SPREAD OF 1926 OUTBREAK.

We may now inquire as to the causes of the 1926 northern outbreak of Toxoptera, which was in an advanced stage before it was observed. It has been noted by Ainslie (1926) and described by Ruggles and Wadley (1927). Severe injury occurred in western Minnesota; it was noticed first and was especially severe in an area in northern Kandiyohi and adjacent counties. In eastern Minnesota a considerable infestation with some injury occurred. Three possible sources of infestation are local winter survival of active aphids, local wintering of eggs, and migration from farther south.

Survival of active aphids in the field has been shown to be impossible in Minnesota. The winter of 1925-26 was somewhat above normal, but not mild enough for Toxoptera to live through. The three-month period averaged about 20° F. in the southern half, with December and January below 20° F. There seems to be no chance that such survival could have occurred.

Production of sexual forms and eggs by Toxoptera in Minnesota has been shown to be uncommon. The fall of 1925 was even less favorable for their development than usual, owing to general cold weather in October. At New London, in Kandiyohi County mean temperature for October was 38° F., with a minimum of 6°. November was too cold for development. Even aphid species regularly wintering as eggs were reduced in numbers by these conditions, and were scarce the next spring, according to students of the group in Minnesota. The doubt that eggs endure Minnesota winters well has been pointed out. Delay in reaching summer food-plants by aphids wintering as eggs is a third and very serious difficulty in connecting this outbreak with such wintering. In the area most affected, aphids were very numerous before June 15; in some cases large oats in joint were being destroyed, and the aphids must have reached several thousand per square foot. March and the first half of April were too cold for Toxo-

ptera's development at New London and spring grain was not up. In the latter half of April, averaging about 50° F.; May, averaging 60° F.; and the first half of June, averaging 63° F.; about 4 generations of *Toxoptera* might develop. If they originated from winter eggs, the first two generations must have developed on some winter food-plant, only about two on spring grain. Estimating a possible increase of 13 times per generation, and 45,000 per square yard as maximum population; if four generations developed on oats the minimum initial

infestation required would be $\frac{45,000}{13^4}$, or less than 2 per square yard;

but if only two generations developed on oats, over 250 per square yard would be required. It is very doubtful if development of such numbers as the latter on grasses, and migration to grain, could take place without attracting attention. These approximations show the difficulty of believing such an outbreak to be due to wintering of eggs. Great concentration of *Toxoptera* occurred on oats not many days after aphid migrants would have been leaving winter food-plants.

As survival of active aphids was impossible, and infestation from winter eggs very improbable, there remains the possibility of migration. Conditions exist which makes this seem probable. Kansas entomologists did not observe *Toxoptera* in early spring, 1926, but Prof. C. E. Sanborn told the writer of infestations in central Oklahoma in winter and early spring. This was the nearest known infestation to western Minnesota. The occurrence of unusually favorable winds in 1926 has already been recorded (Table XXV, Figs. 20 and 21). In their dates, direction, and distance they would be fitted for the migration needed to explain the Minnesota infestation. About four generations could develop from the windy period of April 19-20 to June 15; something over three generations from May 5-7 to June 15. The initial infestation required would thus be little higher than that observed in 1927.

The wind would be expected to deposit migrants over a wide area. The area in which great numbers were first noticed covered parts of three counties. However, in other counties in that part of Minnesota injury was considerable and large numbers were reached almost as early. Professor Drake told the writer of one infestation in western Iowa. Mr. Nelson of Brooten, Minnesota, who became familiar with the green bug during the outbreak there, described similar infestation and injury near Jamestown, North Dakota, late in June. Some reports were made of *Toxoptera*, in South Dakota (Insect Pest Survey); Mr. McPadden, of Webster, South Dakota, described injury to oats similar to work of *Toxoptera*. A number of counties in western Minnesota show large decreases in oat yield not explained by barley yields (see Ruggles and Wadley). A considerable infestation may exist without being observed by farmers. It seems likely that the original infestation was wide-spread in western Minnesota and eastern Dakotas, and perhaps in northwestern Iowa. Farther south the earlier onset of summer would be expected to prevent great increase following infestation.

The rainfall was variable and somewhat deficient in western Minnesota and neighboring states in April, May and early June, with rather long rainless periods. In the area most injured it was especially dry; May had only 1.15 inches of rain, and only two rains of over one-fourth inch fell from April 15 to June 12. This condition undoubtedly favored increase. It seems unlikely that enemies were very active at the temperatures prevailing. Large numbers were reached and migrants left from the middle of June to early July in western Minnesota.

In the eastern Minnesota infestations, the source seems less likely to have been migrants from the south. Large numbers were not reported until July; only late-sown grain was much injured. It seems certain

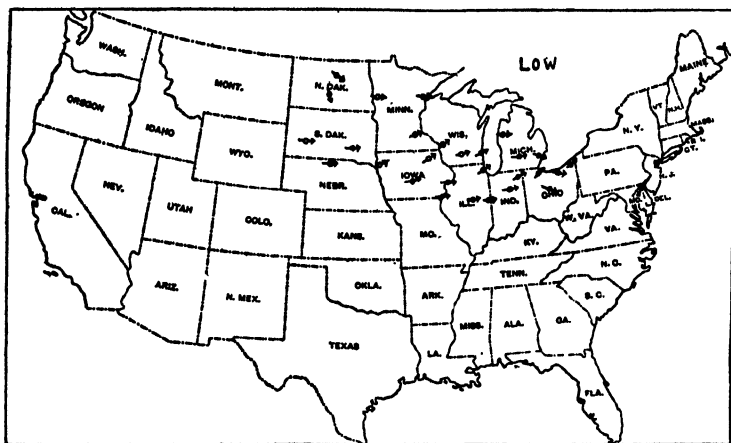


Fig. 22. Wind conditions, June 22, 1926. From daily weather map.

that infestation came later here. This may also be true of some late infestations in extreme northern Minnesota. At Duluth, oats not up before June 10 at the state experiment farm were infested by June 20; at St. Paul, *Toxoptera* were seen June 22. Development of Coccinellid larvæ indicated aphid abundance beginning about July 1. Dr. Fracker told the writer of general infestation in Wisconsin, with injurious numbers reached at several points; the Insect Pest Survey reported scattered infestations in Michigan, northern Ohio, and northern Indiana. In these states the largest numbers occurred in July. A southwest wind April 29 and 30 had a total mileage, at several points in its path, of 400 to 700 miles, averaging 560; this would not be sufficient to bring aphids the 700 or more miles from Oklahoma to Wisconsin. The south winds noted seemed less likely to cause this infestation because a large acreage of winter grain was not present directly south of this area.

Migrants were leaving in swarms in the most heavily infested western area by the middle of June, and probably before in smaller

numbers; they were migrating somewhat later from neighboring areas, and some must have been flying nearly all through June. Strong west winds blew in the Dakotas and Lake States on June 6-8, 17-18, and 22-23 (see Fig. 22). Balloons released in grain rust studies in Minnesota were recovered as far away as Ohio. With migrants abundant in western Minnesota, and winds blowing that were capable of carrying them hundreds of miles, infestation of eastern Minnesota and Wisconsin and possibly of spots farther east, is readily accounted for. Rainfall was variable and somewhat short in this region, during much of this time of increase. Enemies attacked the aphids, but did not seem abundant enough to control them.

The infestation varied considerably over the territory. This could result from variable conditions affecting increase as well as from variation in original infestation. The most noticeably variable factor affecting increase was rainfall. Ruggles and Wadley show that dates of reports of large numbers when mapped show a roughly concentric succession around the area most injured. This can hardly be due to successive migrations, since the winged forms produce nearly all wingless progeny, and migrations must thus be at least two generations apart. It is believed that in the small area first injured, large numbers developed earliest because of the local rainfall shortage; around it the greatest numbers came somewhat later; they were probably later farther north because of lower temperatures, and farther south because of more rain in June. In the territory farther east, infested by migrants from this territory, large numbers of course developed still later, again with local variations. It is believed that the concentric appearance is best explained by these differences.

The outbreak may largely be explained by earliness of infestation in the west, conditions favoring migration eastward, light rainfall, and scarcity of enemies. Temperatures of spring and summer are of little help in explaining it. March, April and July temperatures in Minnesota were nearly normal; it was too cold for *Toxoptera*'s development before the middle of April. May was about 5° F. above normal, June about 3° below; these temperatures were somewhat favorable, as *Toxoptera* could be active over a considerable period when its enemies were checked by cold. Even with normal temperatures, however, considerable increase could have occurred.

It is believed that migrants from the southwest arrived in April or early May and gave rise to widespread and variable infestation in western Minnesota and eastern Dakotas, that migrants from this territory in June infested areas farther east.

PROBABILITY OF NORTHERN OUTBREAKS.

It seems likely that *Toxoptera graminum* will seldom be generally injurious in Minnesota. It is not adapted to wintering there; the winter eggs may enable it to winter somewhat farther north than active aphids can survive, but are not efficient as a hibernating stage in Minnesota.

It does establish itself in the northern states by migration, usually too late to be very injurious except perhaps to very late grain. It has been as far west as Texas at least since 1890, and has only once been seriously injurious in the north. It can be seen that the 1926 outbreak was due to several favorable circumstances occurring together; including winds suitable for a long migration early in the season, migrants on the wing at the time the winds blew, and dry weather in the north favorable for increase. According to Table XXV, something like one year in five has suitable winds. It is doubtful if winds are as favorable as in 1926 even that often. According to figures given in Weather Bureau Bulletin W for several points in western Minnesota, a dry May (with less than 2 inches rainfall) occurs on the average about one year in four. The early wind and later dryness would not be expected to coincide more than one year in twenty, unless they are correlated, which does not appear to be the case. The chance of migrants being abroad in numbers in the southwest, at the time of winds between April 15 and May 15, seems good, but cannot be estimated with our present data.

SUMMARY.

* The life history of *Toxoptera graminum* was found to be similar in many respects to that of other common aphids. Life history data are recorded.

Extensive studies under controlled temperatures, both moderate and extreme, have been carried out, for the first time with this species. It has developed from 7° to 33° C., the most rapid development coming at 30°, the maximum reproduction about 22°. It was quickly killed by temperatures as low as -15° or as high as 42°. At temperatures less extreme, but still above or below the range of development killing was slower. Inactivity due to cold was fatal in a few weeks at most. Sexual forms were reared only at temperatures averaging below 22° C. More winged forms appeared at variable temperatures averaging about 15° C. than at other temperatures.

A wide range of relative humidity had little or no direct effect on the species.

When days were shortened to less than 12 hours, at suitable temperatures, sexual forms appeared. They continued to develop as long as days were short. Reproduction rate was much lower with short days; winged forms were more numerous at certain day-lengths.

Rain caused a definite reduction of numbers by mechanical beating off and burial. Snow covering was not fatal; it may give protection against brief cold snaps. Wind was a stimulus and aid to flight.

Food-plants are much injured by feeding because of a characteristic injury, involving destruction of chlorophyll. Many grasses are listed as food plants, but only wheat and oats have been greatly injured. Studies were made of the degree of infestation of some grasses, since little information could be found on this subject. Those studied could be classified as preferred, second-choice and temporary food plants, except some that were not attacked at all. Lessened reproduction and increased migration were encountered on food plants other than preferred. Curtailed or unsatisfactory nutrition tended to stop reproduction and cause migration; it caused a great increase in winged forms in the succeeding generation. Wheat and oats were unsatisfactory as food after the heading stage.

A study of factors producing biological forms was made, for the first time with this species. Winged forms appeared when the parent generation had had poor nutrition, and to a certain extent under variable temperatures averaging about 15° C., as in spring and fall. Some evidence was found of an influence of day-length also. Winged adults produced nearly all wingless progeny under all conditions. Males and oviparous females appeared under a combination of shortened days and temperatures averaging below 22° C.; no other conditions affecting their appearance have yet been noted. Sex-producing influences must be at work two generations before sexes mature; wing-producing influences, more than one generation.

Limited migration on foot, especially by adults and large nymphs, occurred; usually only where food became unsatisfactory. Migration by winged adults took place even when food was satisfactory. Flight depends largely on the wind, and evidence was found of migrations up to several hundred miles in this manner.

Population increase was difficult to calculate because of overlapping generations; developmental rate and reproduction early in adult life are important factors in increase. Potential increase at several temperatures is calculated. It seems likely that a population increase of 13 times per generation may be used as the reproductive capacity of the species. In the field population may reach one to several thousand per square foot before killing grain.

The principal enemies were Coccinellids, Syrphids, and hymenopterous parasites. Chrysopids, Cecidomyids, and general predators are of slight importance. Coccinellids showed great power of control, and held up well in numbers between aphid outbreaks. Syrphids were of less importance. Data on life history and aphid consumption for these two groups are recorded. Hymenopterous enemies have been present only in small numbers, in Minnesota; one species has shown considerable power of control in the south, according to literature.

Toxoptera graminum has been important in lower temperature latitudes where grain is grown, in several continents. In the United States the worst injury has been in the south and border states, especially Oklahoma and Texas.

The species has been most often injurious in regions where rainfall is sufficient for grain-production; but rather light, with long intervals between rains, during the period of injury to grain. In more humid regions injury has often accompanied rainfall shortage. This is ascribed to known reduction of numbers caused by rains.

Summer conditions severely check the green bug, according to the literature and field observations; they include food scarcity, increased migration hazards, and activity of enemies, and in the southern part of the United States, high temperatures.

Wintering in the egg stage is of little economic importance, owing to delay in producing migrants in spring. The sexual forms and eggs seem to develop in the field in Minnesota but seldom, owing to earliness of cold weather. Nymphs and adults winter in the fields in the southern states; winter months having mean temperatures of 30° F. with only few and brief approaches to 0° F. represent about the limit of severity for wintering. A large proportion of the outbreaks occur where this wintering takes place. Migration from wintering places to the north appears to occur in many seasons; usually only part of the distance is covered at one migration, the remainder by later generations. If the infestation becomes established well in advance of summer conditions, considerable injury may result. Usually infestations by migrants is too late to become very important. Conclusions are based on records in the literature, field observations and experiments under controlled conditions.

The 1926 outbreak in the north probably originated from migrants from the southwest. The conditions which existed were such as to make it seem very improbable that other sources were concerned, but were unusually favorable for migration. Winds of dates, direction, and duration suitable to explain infestation occurred; dry weather later was favorable for development. Reports indicate a widespread, though variable, infestation in western Minnesota and Dakota. Migrants leaving the first area in June probably infested territory farther east, where injury seemed to have developed later.

Severe northern outbreaks will probably occur but seldom; that of 1926 seemed to result from a combination of conditions which are not expected to coincide often. Some injury to late sown grain may occur more frequently. (6)

LITERATURE CITED.

- Ackerman, Lloyd. 1926. The physiological basis of wing-production in the grain aphid. Jour. Exp. Zool., 44: 1-62.
- Ainslie, C. N. 1926. Notes on the recent outbreak of *Toxoptera graminum*. Jour. Ec. Ent., 19: 800-801.
- Ashmead, W. H. 1900. Classification of Ichneumon flies or the superfamily Ichneumonoidae. Proc. U. S. Nat. Mus., 23: 1-220.
1903. Classification of the gall wasps and the parasite Cynipoids, or the superfamily Cynipoidea. Psyche, 10: 7-13; 59-73; 140-155; 210-216.
1904. Monograph of the Chalcidoidea. Mem. Carnegie Mus., 4: 225-551. Pls. 9.
- Bachmetjew, P. 1901. Experimentelle entomologische studien. I. Temperaturverhältnisse bei Insekten. 160 pp. Leipzig.
- Banks, N. A. 1903. A revision of the nearctic Chrysopidae. Trans. Am. Ent. Soc., 29: 137-149. 1 pl.
- Bentley, G. M. 1914. Ninth Ann. Rept. Tenn. State Bd. Ent., pp. 120. (*Toxoptera* treated pp. 27-28.)
- Brittain, W. H. 1921. Some factors influencing the occurrence of alate forms in certain Aphididae. Acadian Ent. Soc. Proc., 1921, No. 7.
- Chapman, R. N. 1925. Animal ecology with especial reference to insects. Mimeographed. Pp. 370. Minneapolis.
- Collins, C. W. 1915. Dispersion of gipsy-moth larvae by the wind. U. S. D. A. Dept. Bul. 273; pp. 21; pls. 6.
- Cook, W. C. 1927. Some effects of alternating temperatures on the growth and metabolism of cutworm larvae. Jour. Ec. Ent., 20: 769-782.
- Cutright, C. R. 1924. Bionomics of *Hippodamia tridecumpunctata* L. Ann. Ent. Soc. Am., 17: 188-193.
- Davidson, J. 1924. Factors which influence the appearance of the sexes in plant-lice. Science, n. s. 59: 364.
- Davis, J. J. 1916. *Aphidoletes meridionalis*, an important dipterous enemy of aphids. Jour. Agr. Res., 6: 883-887, figs. 4, pl. 1.
- Elton, C. S. 1925. The dispersal of insects to Spitsbergen. Trans. Ent. Soc. London, 1925: 289-291.
- Ewing, H. E. 1926. Wing-production in plant-lice. Am. Nat., 60: 567-577.
- Felt, E. P. 1917. A study of gall midges, VI. 33rd. Rept. N. Y. State Ent., pp. 76-205.
- Forbes, S. A. 1905. A monograph of insects injurious to Indian corn. Part II. 23rd Rept. Ill. State Ent., pp. 280, pls. 8, figs. 238.

- Gahan, A. B. 1911. Aphidiinae of North America. Md. Agr. Exp. Sta. Bul. 152: 147-200, figs. 11.
- Garman, H. 1926. Two important insect enemies of bluegrass pastures. Ky. Agr. Exp. Sta. Bul. 235.
- Garner, W. W. and W. A. Allard. 1922. Photoperiodism, the response of the plant to relative length of day and night. Science, 55: 582-583.
- Girault, A. A. 1917. The North American species of *Pachyneuron* with three new species (Chalcid flies). Psyche, 24: 88-91.
- Glenn, P. A. 1909. The influence of climate upon the green bug and its parasites. Bul. Univ. of Kans., 9: 165-200, figs. 18.
- Gregory, Louise H. 1917. The effects of starvation on wing-development of *Microstiphum destructor*. Biological Bul. 33: 296-303.
- Hartley, E. A. 1922. Some bionomics of *Aphelinus semiflavus* (Howard). Ohio Jour. Sci., 22: 209-236. 1 pl., 1 fig.
- Hayes, W. P. 1922. Observations on insects attacking sorghums. Jour. Ec. Ent., 15: 349-356.
- Headlee, T. J. 1914. Some data on the effect of temperature and moisture on the rate of insect metabolism. Jour. Ec. Ent., 7: 413-417.
- Headlee, T. J., and J. W. McColloch. 1913. The chinch bug. Kans. Agr. Exp. Sta. Bul. 191: 281-353; figs. 13, pls. 6.
- Howard, L. O. 1908. Upon the aphid-feeding species of *Aphelinus*, Ent. News, 19: 365-367.
1921. Rept. of Ent., U. S. D. A., 1921.
- Hunter, S. J. 1909. The green bug and its enemies. Bul. Univ. of Kans., 9: 1-163; 201-222; pls. 3, figs. 47.
- Kelly, E. G. 1917. The green bug (*Toxoptera graminum* Rond.) outbreak of 1916. Jour. Ec. Ent., 10: 233-248.
- Lefroy, H. 1908. Imported insect pests. Agr. Jour. India, 3, part 3: 237-244.
- Luginbill, P. 1914. South Carolina Dept. Agr. Rept. 10, p. 264. (In S. C. Yearbook for 1913.)
- Luginbill, P., and A. H. Beyer. 1918. Contribution to the knowledge of *Toxoptera graminum* in the south. Jour. Agr. Res., 14: 97-119, pl. 1, figs. 8.
- Marcovitch, S. 1924. The migration of the Aphididae and the appearance of the sexual forms as affected by the relative length of daily light exposure. Jour. Agr. Res., 27: 513-522.
- McAtee, W. L. 1913. Relations of birds to grain aphids. U. S. D. A. Year Book, 1912, pp. 398-404.
- Merriam, C. H. 1895. The geographical distribution of animals and plants in North America. U. S. Dept. Agr. Year Book, 1894: 203-214.
- Metcalf, C. L. 1911-1913. Life history of Syrphidae. Ohio Naturalist (now Ohio Jour. Sci.). Parts in Volumes 11, 12, 13.
1916. Syrphidae of Maine. Maine Bul. 253, pp. 72, pls. 9.
- Moore, W. 1914. A comparison of natural control of *Toxoptera graminum* in South Africa and the United States. Ann. Ent. Soc. Am., 7: 77-85. (A fuller treatment is given in Agr. Journ., Union of S. Africa, Vols. 6 and 7, 1913-14.)
- Morrill, A. W. 1913. Notes on important insects of the year. Fifth Ann. Rept. Ariz. Comm. Agr. and Hort., pp. 33-48.
- Palmer, M. A. 1914. Some notes on life history of lady beetles. Ann. Ent. Soc. Am., 7: 213-238. 3 pls.
1917. Additional notes on heredity and life history in the Coccinellid genus *Adalia* Mulsant. (Contains records of hibernation of *Hippodamia convergens*.) Ann. Ent. Soc. Am., 10: 289-302.
- Phillips, W. J. 1915. Further Studies on the Embryology of *Toxoptera graminum*. Jour. Ag. Res., 4: 408-404, 2 plus.
- Piper, C. V. 1924. Forage plants and their culture. Pp. 671. Macmillan Co.
- Reinhard, H. J. 1927. The influence of parentage, nutrition, temperature and crowding on wing-production in *Aphis gossypii* Glover. Texas Agr. Exp. Sta. Bul. 353: 19.
- Rondani, C. 1852. Lettera al L. Prof. G. Bertoloni: Nota sopra una specie di Afide, volante in numerosa torma nella citta' di Parma. Nuova Ann. Sci. Nat. Bologna, Ser. III, T. 6, pp. 9-12.

- Ruggles, A. G., and F. M. Wadley. 1927. The green bug in Minnesota. Jour. Ec. Ent., 20: 321-327. 1 fig.
- Sanborn, C. E. 1916. The green bug. Okla. Agr. and Mech. College, Ext. Circ., 30: 4.
- Sanborn, C. E., W. J. Brown and G. A. Bieberdorff. 1926. Entomology. In Bien. Rept. Okla. Exp. Sta., 1924-26, pp. 38-43.
- Sanderson, E. D. 1908. The relation of temperature to the hibernation of insects. Jour. Ec. Ent., 1: 56-65.
- Shinji, G. O. 1918. A contribution to the physiology of wing-development in aphides. Biol. Bul. 35: 95-116.
- Shull, A. F. 1926, 1927. Papers on duration of light and life cycle of aphids. Abstracts in Anat. Rec., 34: 168; 37: 136.
- Smith, R. C. 1922. The biology of the Chrysopidae. Cornell Mem. 58: 72, pls. 14, figs. 10.
- Stevens, N. M. 1905. A study of the germ cells of *Aphis rosæ* and *Aphis aenotheræ*. Jour. Exp. Zool., 2: 213-334.
- Tucker, E. S. 1918. Notes on the green bug (*Toxoptera graminum* Rond.) in Texas. Trans. Kans. Academy of Sci., 28: 276-291.
- Van der Goot, P. 1915. Beitrage zur Kenntniss der Hollandischen Blattlaus. Pp. 600. Berlin.
- Viereck, H. L. 1916. The Hymenoptera, or wasp-like insects, of Connecticut. Conn. Geol. and Nat. Hist. Survey, Bul. 22: 824, pls. 10, figs. 15.
- Wadley, F. M. 1923. Factors affecting the proportion of alate and apterous forms of aphids. Ann. Ent. Soc. Am., 16: 279-303, figs. 2.
1929. Observations on the injury caused by *Toxoptera graminum* Rond. (Homoptera: Aphididae). Proc. Ent. Soc. Wash., 31: 130-134.
- Walton, W. R. 1921. The green bug or spring grain aphid. U. S. Dept. Agr. Farmers' Bul. 1217. Pp. 11, figs. 9.
- Washburn, F. L. 1908. A. The so-called "green bug" and other grain aphids of Minnesota in 1907. Univ. of Minn. Agr. Exp. Sta. Bul. 108, pp. 257-280, pl. 1, figs. 15. (First published as a special report.)
1908. B. The spring grain aphid or the so-called "green bug." In 12th Rept. State Ent. of Minn., pp. 42-46.
1908. C. Sexual forms of *Toxoptera graminum* Rond. Can. Ent., 40: 53-54.
- Webster, F. M. 1892. Notes on the grain Toxoptera. Insect Life, 4: 245-248.
1914. An unrecorded parasite of *Toxoptera graminum*. Jour. Ec. Ent., 7: 403-404.
1916. The spring grain aphid or "green bug" in the southwest, and the possibilities of an outbreak in 1916. U. S. D. A. Office of Sec., Circ. 55. Pp. 3, figs. 3.
- Webster, F. M., and W. J. Phillips. 1912. The spring grain aphid or green bug. U. S. Bu. Ent., Bul. 110, n. s., pp. 144, pls. 9, figs. 48, diagrams 5.
- Wilson, E. B. 1925. The cell in development and inheritance. Pp. 1232, figs. 529. Macmillan Co.

THE HABITS OF LEAF-MINING COLEOPTERA ON BARRO COLORADO ISLAND, PANAMA.

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The writer spent several months on Barro Colorado Island, Canal Zone, Panama, rearing and studying leaf-mining insects. The Coleoptera of the families Chrysomelidæ, Curculionidæ and Buprestidæ have been studied sufficiently to warrant a few notes concerning their habits. The drawings were made, and notes taken, while on the Island. The host plants were determined by Dr. Paul C. Standley of the Field Museum of Natural History, Chicago, Ill. The Buprestidæ were determined by Mr. W. S. Fisher and the Curculionid identified by Mr. L. L. Buchanan both of the U. S. National Museum. One species from Panama City is added.

The Chrysomelidæ (Hispidi) were the most numerous of the leaf-mining Coleoptera. The mines of these species were scattered, seldom more than one or two on a single plant, and it was necessary to do considerable collecting in order to get sufficient material to rear and study their habits. The adults were frequently collected as they were found resting or feeding on their food plants. All of the Chrysomelidæ have been turned over to the National Museum for identification and study. At present the group is not in satisfactory condition and it will require some time before the material can be properly worked up.

The remaining leaf-mining Coleoptera consist of a single Curculionid, *Prionomerus abdominalis* Boh., and a few Buprestidæ. The mines of some of the Buprestidæ were abundant while others were scattered, a single plant bearing but one or two mines. The adults of a few species were collected while feeding or ovipositing on their favorite food plants.

Prionomerus abdominalis Boh., (Plate I, Fig. 2) probably represents one of the extremes in leaf-mining insects. While we usually think of a miner as an insect producing a more or less flat mine within the leaf, this species produces a large mussy blotch that bulges three quarters of an inch when the larvæ have completed their growth and spun their

cocoons within the leaf. They mine the leaves of Lauraceae, making large blister-like mines that cover over one half or three quarters of the leaf surface. The eggs, six or seven in number, are inserted in the lower side of the leaf usually near a vein at the base of the leaf. At first the larvæ produce a broad linear mine which follows the edge of the leaf and is crowded with an abundance of black frass. Later the larvæ work towards the center of the leaf and mine an area somewhat devoid of frass. All of the larvæ continue to mine and complete their growth in the same leaf. When ready to transform, a large ball, one half or three quarters of an inch in diameter, is formed in the center of the mine composed apparently of a malpighian secretion. This has the appearance of coarse black silk. Within this mass the larvæ make individual cells. The adults emerge in the mine and cut their way to freedom through the surface of the leaf.

Hylaeogena alibertiae Fisher, (Plate I, Fig. 1). This species was described in Ent. Soc. Wash 31, 1929 from a specimen reared by the writer from the host plant *Alibertia edulis* (L. Rich) A. Rich. The leaves of this plant are small and a single larva mines a leaf. The mine starts at the base of the leaf where the egg is laid. The first part of the mine is jammed with abundant frass but as the mine is broadened the frass is arranged in a more or less neat central band. Nearly the whole leaf area is mined before the larva matures. A circular case is cut from the two leaf surfaces and within this the larva spins a transparent silken cocoon.

Hylaeogena coelicolor Obenb., (Plate I, Figs. 3 and 4), was reared on several occasions from a plant which has not been determined. A batch of three or four eggs are laid on the underside of the leaf and covered with a mass of excrement or regurgitated food. This material is yellow in color and laid down in streaks as though applied with the mouth. On hatching the larva makes a short, linear mine, then produces a blotch covering about three quarters of the leaf surface. The mine is green in color and visible from both surfaces of the leaf, but more plant tissue is removed from the upper than the lower side of the leaf. The frass is laid down in zig zag bands. The larva cuts a circular case from the leaf, the upper and lower epidermal layers forming the upper and lower sides of the case respectively. To emerge the adult cuts a circular cap considerably smaller than the diameter of the case.

Pachyschelus atroviridis Fisher, (Plate II., Figs. 7 and 8), is one of the most abundant species of leaf-mining Buprestidæ on Barro Colorado Island. The food plant, *Serjania*, is likewise common and forms one of the conspicuous low growing plants. The adults were often seen feeding or ovipositing in considerable numbers on this plant. Sometimes as many as twenty-five or thirty adults were seen on a single plant and almost every leaf showed eggs or mines. Two or three eggs are laid on the under side of the leaf between two of the larger veins and covered with a triangular patch of excrement or regurgitated food. This covering is securely fastened at the base but loose at the

distal end. It consists of two thin layers of material rather than a thick mass. When the eggs hatch the larvæ enter directly into the leaf and make at first a short linear mine. Later the mine is broadened considerably. The frass is scattered in irregular masses and in the narrower portions is laid down in short arc-like bands. When ready to transform, the larva cuts a circular case from the leaf. This operation was observed many times. The larva clears a circular area in the mine of the desired size (the same diameter as the length of the larva). This area is transparent with only the larger veins left, giving it a skeletonized appearance. A cleaner job is done than in the rest of its operations where more cells are left on the floor of the mine. The larva then commences cutting the two surfaces of the leaf about the edge of the circular area stopping now and then to spin a few threads to hold the upper and lower portions of the case together. In about two hours the case is entirely severed from the leaf with the exception of three or four larger veins which hold the case in position until the larva is ready to abandon the leaf. When sufficient silk has been spun to properly fasten the upper and lower portions of the case together, the larva severs these ties by violent movements of its head. The drying of the veins also assist the larva in freeing itself from the leaf. Finally the little case pops from the leaf with considerable force. Those observed at the laboratory were sometimes carried for several inches. The following day the larva is much shrunk and enveloped in considerable silk but the pupa is not formed until the second day after the larva starts the construction of its case. The completed case is opaque and brown in color.

Pachyschelus atrifrons Fisher, (Plate II, Figs. 5 and 6) was fairly common but the writer seldom found more than one or two mines on a single plant. The larvæ mine the leaves of *Acalypha diversifolia* Jacq. The mine starts as a narrow trail along the edge of the leaf, gradually becoming broader until a distinct blotch is produced. At first the frass is laid down in a central line but later it is scattered in an irregular band along the sides of the mine. Transformation occurs in a semitransparent, papery cocoon spun in the mine.

Pachyschelus psychotriæ Fisher (Plate III, Figs. 12, 13, 14). Three eggs were laid on the underside of a leaf of *Psychotria carthaginensis* Jacq. These eggs were covered with a gelatinous scale like mass probably from the mouth of the beetle. One of the eggs hatched and produced a long mine, at first quite narrow and crowded with frass but later becoming broad with the frass scattered along the sides of the mine. The larva spins a silken cocoon within the mine that is securely fastened to the bottom of the mine and is covered with yellow frass pellets.

Pachyschelus frosti Fisher. A single female was collected on Burro Colorado Island, but its food plant and nothing concerning its habits are known.

Brachys fulgidus Fisher (Plate IV, Fig. 15). The mines of this species were collected by Mr. August Busck in Panama City on the

leaves of *Ficus elastica* Roxb. The original description and habits of the miner appear in Proc. U. S. National Museum, Vol. 62, Art. 8, pages 44-45, 1922. The mines are conspicuous and sometimes as many as twelve were found on a single leaf.

A mine of *Brachys* was found on *Faramaea occidentalis* (Plate IV, Fig. 16). A single egg is laid on the upper side of the leaf. The mine is at first narrow with a moderate amount of frass, later it broadens into a more or less blotch mine with the frass arranged along the edges of the mine. The naked pupa was found in the mine but the adult was not reared.

Another species of *Brachys* was frequently seen on *Inga* spp. (Plate IV, Fig. 17) but the adults were never reared. Apparently the larva escapes from the mine to pupate, for all of the mines show distinct round holes through the lower side and no pupæ were found in the mines.

On *Phryganocydia corymbosa* (Plate III, Fig. 10-11) a very characteristic mine was often collected but unfortunately adults were not reared. There are two parts to the mine, one filled with abundant black frass and the other almost without frass. The larva spins a pupal case of silk in the mine which is suspended between the two surfaces of the leaf by small masses of frass. Larvæ were examined by Dr. Adam Boving and he states that they belong to the group *Pachyschelus*.

It is evident that our knowledge of the leaf-mining Coleoptera of the American tropics is scant. Many adults of leaf-mining insects have, of course, been taken but the collector has too often shown no primary interest in their habits or food plants. Aside from the Buprestidæ, practically no studies have been made of the life-histories of tropical leaf-mining Coleoptera. Even the habits of certain genera of this group namely: *Lius*, *Liopleura*, *Liopleurella* and *Callimiora*, are little known. It is believed that they are largely leaf-mining species. Tropical Hispini are numerous, little studied and difficult to identify. The writer's material, which comprise the most extensive group reared and studied in the tropics, awaits determination. The Curculionid leaf-miners are probably somewhat limited in numbers and at present are known only from the genus *Prionomerus*. *Orchestes*, a large genus having its origin and greatest development in Europe, and at present unknown in the tropics, may yield some interesting species.

European students of leaf-mining insects have not collected in the tropics. As in America, systematists have collected extensively. The field for the study of leaf-mining insects in the Old world tropics is open.

The abundant systematic writings of Schwartz, Blatchley, Leng, Horn, Van Duzee, Chevrolet, Champion, Hamilton and others have included many notes on tropical species of Florida and the West Indies. Van Dyke and Fall have contributed to tropical species of California. The *Biologia Centrali Americana* lists a great many tropical species and numerous food plants. The only outstanding papers on tropical leaf-mining Coleoptera are those by Mr. W. S. Fisher on the Buprestidæ.

BIBLIOGRAPHY.

- Fisher, W. S. The Leaf-mining Buprestid Beetles of Mexico and Central America. Proc. U. S. Nat. Mus. 62, art. 8: 1-95, 1922.
 A Revision of the West Indian Coleoptera of the Family Buprestidae. Proc. U. S. Nat. Mus. 65, art. 9: 1-207, 1925.
 New Species of Buprestid Beetles from Costa Rica. Proc. U. S. Nat. Mus. 76, art. 6: 1-10, 1929.
 Notes on Leaf-mining Buprestidae (Coleoptera) with Descriptions of New Species. Proc. Ent. Soc. Wash. 31, No. 9: 177-182, 1929.
 A New Leaf-mining Buprestid from the Canal Zone (Coleoptera). Proc. Ent. Soc. Wash. 33, No. 2: 42-43, 1931.

EXPLANATION OF PLATES.

PLATE I.

(Slightly reduced.)

- Fig. 1. Mine of *Hylaeogena alibertiae* Fisher on *Alibertia edulis*.
 Fig. 2. Mine of *Prionomerus abdominalis* Boh., on Lauracæ.
 Fig. 3. Mine of *Hylaeogena coelicolor* Obenb., plant undetermined.
 Fig. 4. Pupal case of *Hylaeogena coelicolor* Obenb.

PLATE II.

(Slightly reduced.)

- Fig. 5. Pupal case of *Pachyschelus atrifrons* Fisher.
 Fig. 6. Mine of *Pachyschelus atrifrons* Fisher on *Acalypha diversifolia*.
 Fig. 7. Gelatinous covering over eggs of *Pachyschelus atroviridis* Fisher.
 Fig. 8. Mine of *Pachyschelus atroviridis* Fisher on *Serjania* sp.
 Fig. 9. Undetermined Coleopterous miner.

PLATE III.

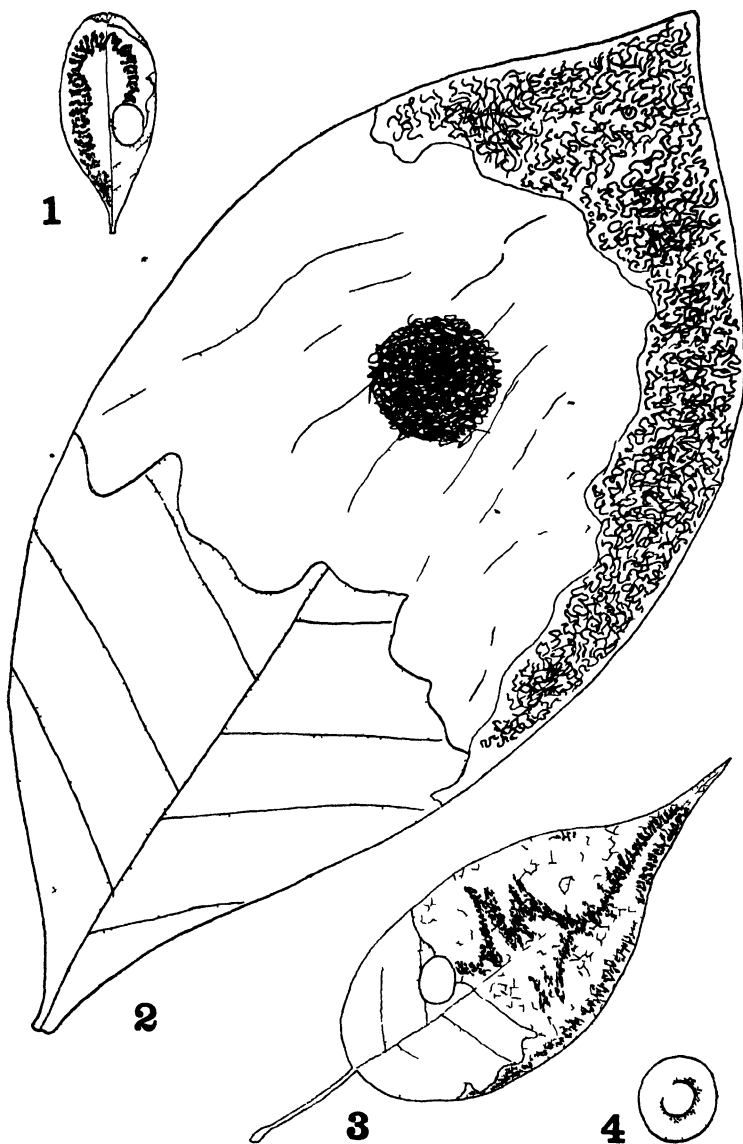
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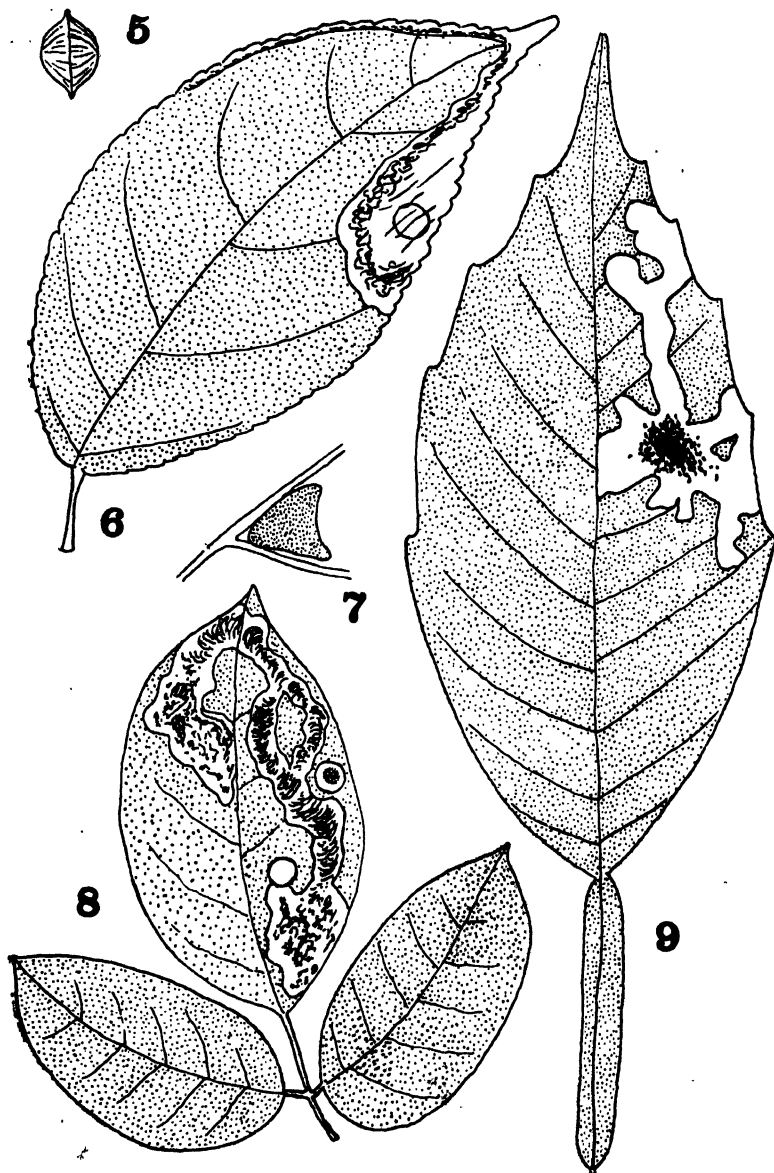
- Fig. 10. Pupal case of undetermined species of *Pachyschelus* on *Phryganocydia corymbosa*.
 Fig. 11. Mine of the above species on *Phryganocydia corymbosa*.
 Fig. 12. Side view of pupal case of *Pachyschelus psychotriæ*.
 Fig. 13. Mine of *Pachyschelus psychotriæ* on *Psychotria carthaginensis*.
 Fig. 14. Top view of pupal case of *Pachyschelus psychotriæ*.

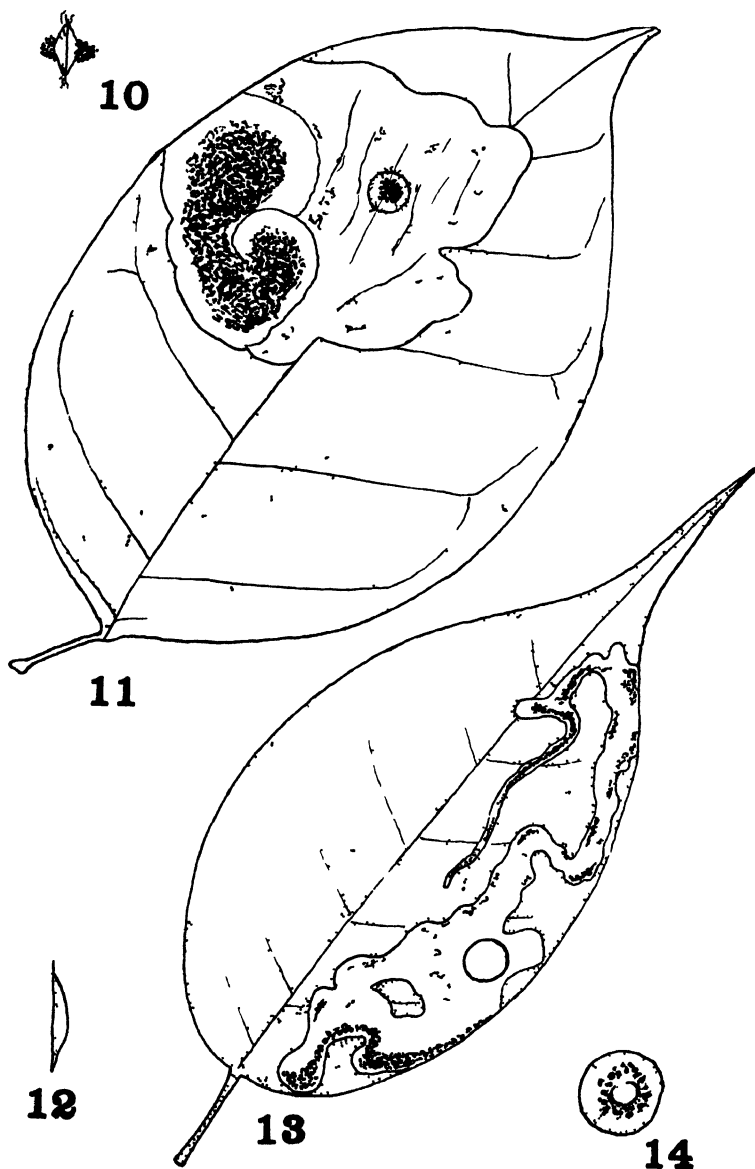
PLATE IV.

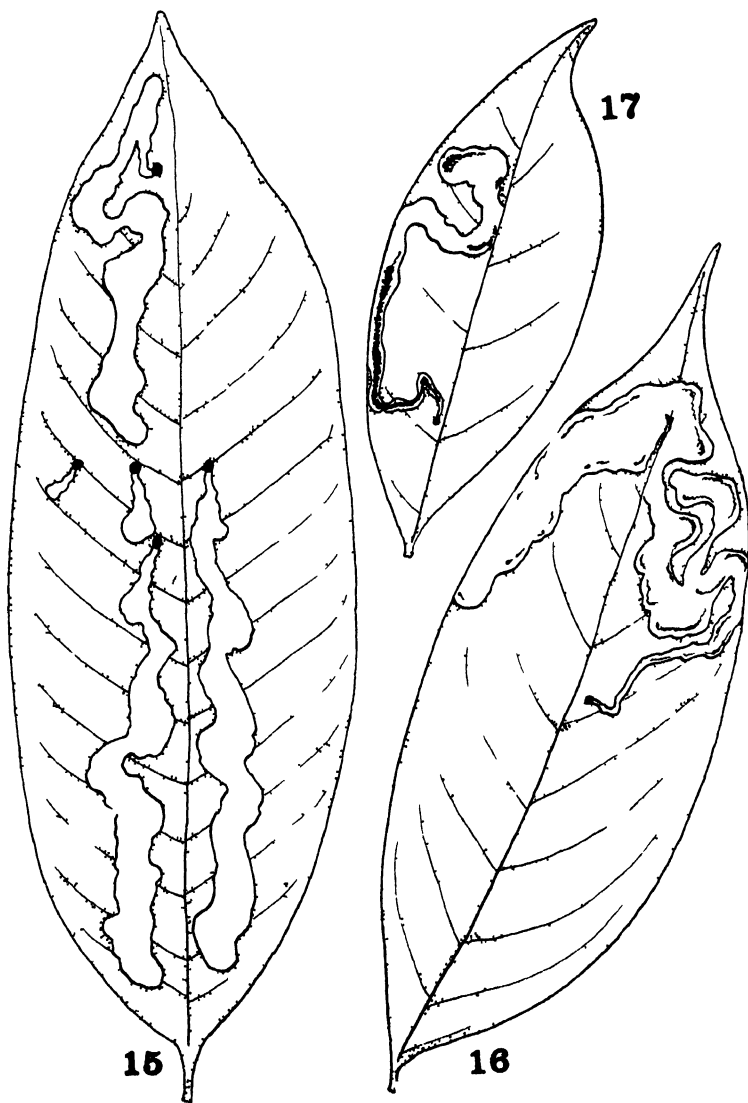
(Slightly reduced.)

- Fig. 15. Mine of *Brachys fulgidus* Fisher on *Ficus elastica*.
 Fig. 16. Mine of *Brachys* sp. on *Famea occidentalis*.
 Fig. 17. Mine of *Brachys* sp. on *Inga* sp.









A ONE-EYED BEE (*APIS MELLIFICA*)

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During an experiment on labor division in a bee colony, a daily marking of newly emerged bees with color-dots on the thorax or abdomen was undertaken. August 4, 1930, a colony of Italian bees was opened for the purpose of marking the young bees. On the inner surface of the inner cover, a few bees were crawling around. Three or four of these were without marking and hence were bees that had emerged within the previous twenty-four hours, the time when the last marking of bees took place. One of these bees attracted my attention by its unusual manner of locomotion. It moved slowly as all young bees do, but backwards instead of forward, in a manner characteristic of crayfish. Taking the specimen in my hand I noticed its extremely narrow face. An examination under the binocular microscope revealed the fact that I was dealing with a freak bee, a bee with only one compound eye. This was situated in the middle of the head, in the frontal region, symmetrically placed. In the laboratory the specimen continued to march backwards and ate in a normal manner the droplets of honey which I offered it from the tip of a toothpick. I could not make it crawl forward even though I placed the honey a short distance in front of its head.

The pictures show the one-eyed specimen with one of its normal sisters of the same age (Plate I, Figs. 1 and 2).

A closer examination showed that the abdomen, with the sting, was normally developed. The thorax and its appendages also could not be differentiated from those of its normal sister. Pollen collecting apparatus was fully developed, the wing venation appeared normal.

As far as the head region is concerned several changes were noticed. The ocelli were absent. The single compound eye was crescent-shaped, with two pointed ends instead of

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kidney-shaped, as in the normal worker. One compound eye of the normal worker, as shown in the illustrations, consists of approximately 5082 ommatidia. In the one-eyed specimen the ommatidia are much larger, because the one eye has the same area as the normal compound eye, but consists only of approximately 3525 ommatidia.

The vertex is swollen and, in combination with the occiput and the genæ, it represented a ring-like structure, interrupted only by the insertion of the mouthparts. The mouthparts were normally developed and showed exactly the same dimensions as the mouthparts of the normal sister. The antennæ of the one-eyed specimen were shorter and thicker and, even though the face was narrower, the bases of the antennæ were further apart than normal. Between the bases there is a tuft of fine, branched hairs.

To give a clearer picture of the dimensions of the various parts of the head, a few careful measurements were taken on the abnormal specimen and, for the sake of comparison, on the normal sister. These data are as follows:

Measurement	One-eyed Bee, mm.	Normal Bee, mm.
Diameter of antennal scape.....	0.395	0.225
Length of antennal scape.....	1.35	1.6
Distance between the antennal bases.....	0.6	0.27
Diameter of flagellum.....	0.315	0.225
Length of flagellum.....	2.925	3.375
Width of labrum.....	1.215	1.325
Length of labrum.....	0.3375	0.2925
Width of clypeus.....	1.6425	1.171
Length of clypeus.....	1.3050	1.2575
Width of compound eye.....	1.035	1.0575
Length of compound eye.....	2.6	2.565
Width of head.....	3.2175	4.1625
Length of head.....	3.87	3.7125

Repeated thorough examinations of the colony, from which the abnormal specimen was obtained, failed to reveal any bees with similar characteristics. The above described species has been placed for reference in the entomological collection of the University of Minnesota, St. Paul, Minnesota.

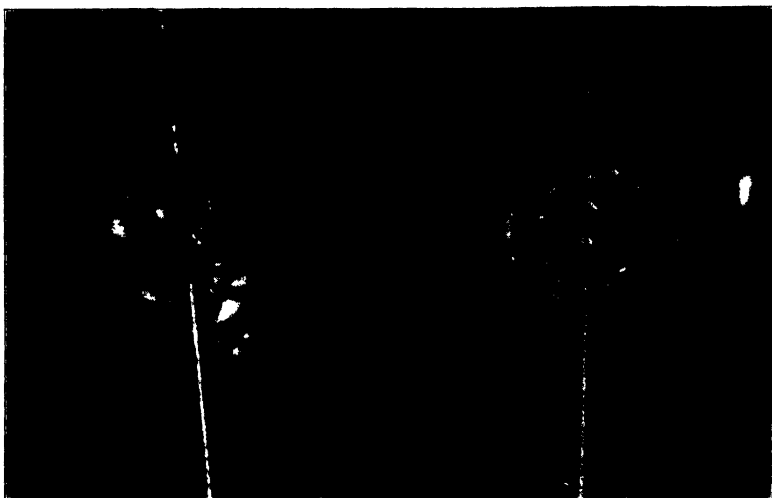


Fig. 1. Honey Bee—Front View.
Left, showing normal bee. Right, specimen with single eye.



Fig. 2. Honey Bee—Side View.
Left, showing normal bee. Right, specimen with single eye.

THE BIOLOGY OF TABANUS LINEOLA FABR.*

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Most studies of North American Tabanidæ have been concerned largely with taxonomy and distribution, with the result that no complete biological study of any species has been made. Hine (1), who was the first investigator to rear a tabanid species from egg to adult, obtained an adult of *Tabanus lasiophthalmus* from the larvæ hatching from one egg mass. Webb and Wells (10) succeeded in rearing three individuals of *T. punctifer* from egg to adult in an average time of 671 days, or about a year and ten months. Stone (9) obtained one adult from an egg mass of *T. atratus*, the black horse-fly. The developmental period was 357 days. Mitzmain (6), working in the Philippine Islands; Neave (7), in Nyasaland; and Isaac (3), in India, have recorded important facts in the life histories of several exotic species. The contributions of workers who have collected Tabanidæ as larvæ and reared them to the adult stage, thus securing partial, but nevertheless valuable records on life histories, have been summarized in a recent paper (8).

This paper is based on life history records of 202 individuals of *T. lineola*, which have been reared from egg to adult under conditions permitting daily observation of all the stages. Field studies on all the stages have accompanied the insectary work. The average incubation period was found to be 4 days, the average larval period 48.8 days, the average pupal period 8.1 days, and the preoviposition period 9 days. The total developmental period has an average duration of 69.9 days. At least two generations occur in Washington County, Arkansas, where all the data recorded here were obtained.

Tabanus lineola is a widely distributed species of horse-fly. Hine (2) records it as "common in eastern North America, and known from as far west as Arizona." He found it to be one of the worst of stock pests in Louisiana. The species is common in most of Arkansas and is exceeded in numbers only

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by *T. costalis*. The adult fly is characterized chiefly by its brilliant green eyes, which are crossed by more than one transverse purple eye stripe (usually two and a partial third), and by the brown or black abdomen which bears three longitudinal, dorsal grey stripes. The length of the fly varies from 12-15 mm.

METHODS.

The rearing technique which proved successful for *T. lineola*, and which subsequently has proved favorable for several other species of Tabanidæ, is not greatly different from that used by Hine (1) for *T. lasiophthalmus*. Half-pint jelly glasses with perforated tin lids were used for cages. These contained half an inch of fine sand which was kept nearly saturated with water. The cages were set with one edge elevated so that their floors formed a fifteen-degree angle with the table, and thus established in each cage a moisture gradient varying from moist sand to sand completely saturated with water. Earthworms, snails, and Crustacea were found to be favorable foods, but the latter were finally used exclusively because they were most easily obtained. The meat from the abdomen of one large crayfish will feed twenty-five nearly grown larvæ for twenty-four hours.

Egg masses were kept in jelly-glass cages until hatching occurred. Immediately after hatching the larvæ from each egg mass were counted. Each larva to be reared was then removed on a wet camel's hair brush and placed in a separate cage, care being exercised to see that each was placed on a particle of food. The larvæ were fed, and all old food removed once every twenty-four hours thereafter until transformation occurred. To locate the small larvæ for observation, and to find their cast skins, the cages were flooded to a depth of about one inch and the contents stirred gently with a brush. When the sand settled the larvæ and any exuvia which they had cast floated at the surface. It was impossible to find the first few exuvia without flooding the cages, and flooding aided greatly in locating even the last skin. It also helped to keep the cages clean. No special care was required at the time of transformation. The pupæ were almost invariably found lying on the surface of the sand.

THE EGG.

Eggs of *T. lineola* are always deposited in masses, which if complete are approximately 10 mm. long by 4 mm. wide, and rounded or pointed at both ends. The individual egg is spindle-shaped, smooth, and about 1.6 mm. long by .3 mm. in thickness. The eggs at the sides of the mass slope downward, forming an angle of about 45 degrees with the median, while those at the center of the mass parallel the median. Incomplete masses, which are the rule, are less than 10 mm. long and are square instead of rounded or pointed at the lower edge. Freshly deposited eggs are milky white in color, but within six hours they become light grey. After twenty-four hours they are dark lead grey, which color they retain until hatching occurs. Occasional masses become almost black before hatching.

Seven egg masses collected in the field produced 454, 155, 267, 363, 364, 376, and 243 larvæ respectively, or an average of 317 larvæ.

THE INCUBATION PERIOD.

The incubation period as observed under insectary conditions varied from 3 to 5 days. Five masses upon which definite observations were made required 5, 4, 3, 4, and 4 days respectively, or an average of 4 days. Temperature is probably the most important factor influencing the incubation period, and eggs exposed to direct sunlight in the field probably hatch more rapidly than those kept in the insectary.

TABLE I.

Tabanus lineola Fabr. Larval Period Fayetteville, Arkansas, 1930.

Length of Larval Period, (Days)	Number of Larvae	Length of Larval Period, (Days)	Number of Larvae	Length of Larval Period, (Days)	Number of Larvae
29	2	46	6	64	1
30	3	47	8	65	1
31	2	48	3	66	2
32	5	49	6	68	1
33	10	50	6	69	3
34	5	51	5	70	3
35	9	52	4	71	5
36	4	53	1	72	3
37	5	54	3	73	1
38	7	55	2	74	1
39	11	56	8	78	1
40	7	57	14	79	1
41	4	58	4	82	1
42	4	59	4	83	1
43	11	60	1	86	1
44	4	62	1	87	2
45	2	63	1	90	1
				92	1

Average larval period

48 8 days

THE LARVA

The full grown larva of *T. lineola* when in a resting position is approximately 21 mm long and 3.2 mm. wide. The color is usually white, but some larvæ take on a slightly yellow or pink cast just before pupation. In common with other larvæ of the genus *Tabanus*, the larva of this species is spindle-shaped, tapering almost to a point at both ends. The head is small, cylindrical, tapers slightly anteriorly, and can be entirely retracted into the thorax. For a detailed description of a larva of this genus see Webb and Wells (16)

THE LARVAL PERIOD.

The larval period of *T. lineola* is comparatively short. Twenty-two individuals reared during the summer of 1930 required 33 days or less to complete their respective larval periods, and the average for 202 individuals was only 48.8 days (Table I). The longest and shortest

larval periods observed were 92 and 29 days, respectively. It seems probable that all eggs which hatch before about August 1 produce adult flies before the winter immediately following. Of a series of larvæ which hatched on July 25, 1930, every individual which survived had produced an adult by September 27, 1930.

In the field, larvæ are usually found in the mud bordering lowland ponds or sluggish water courses.

During the spring of 1930, larvæ were collected from February 12 until May 20. Of the 14 larvæ which completed the cycle, 12 had emerged as adults by June 21, one required until June 30, and the last adult emerged July 11.

NUMBER AND DURATION OF LARVAL STAGES.

The larvæ of *T. lineola* normally pass through four or five larval stages. Variations were observed in which three to seven larval

TABLE II.

Tabanus lineola Fabr. Duration of Larval Stages in Days.
Fayetteville, Arkansas, 1930.

Instar	Maximum	Minimum	Average	Number of Larvæ Observed
First.....	31	5	12.3	195
Second.....	14	2	4.6	195
Third.....	61	1	7.8	195
Fourth.....	63	1	16.6	168
Fifth.....	67	3	21.9	66
Sixth.....	47	5	23.7	12
Seventh.....	18	18	18.0	1

stages occurred, but these were comparatively rare, and it seems probable that some larvæ may have consumed their cast skins occasionally, thus reducing the apparent number of larval stages. The prepupal period was poorly defined in all larvæ observed and is treated as a part of the last larval stage in data presented on stages. Just before transforming, the larvæ undergo a resting period, the beginning of which is indicated by the invagination of the head, and the refusal of food. This period of resting varies in duration from 1 to 57 days. Of 195 larvæ on which observations were made, 27 had 3 larval stages, 100 had 4, 56 had 5, 11 had 6, and 1 larva had 7 stages. An enormous variation occurs in the duration of each of the larval instars, as shown in Table II.

The larvæ of several species of Tabanidæ molt almost immediately after hatching. This has been observed for *T. punctifer* and *T. phaenops* by Webb and Wells (10), for *T. atratus* by Stone (9), for *Chrysops callidus* by Marchand (5), and for several Indian species by Isaac (3). Larvæ of *T. lineola* have never been observed to molt sooner than five days after hatching.

THE PUPA.

The pupa of *T. lineola* is 14 mm. long, and 3 mm. wide at the thoracic region. The color is white just after transformation, but within two hours it has changed to light brown, which color it retains until the adult emerges. A double row of large spines encircles the posterior border of abdominal segments 2-7. A pair of large, raised, lateral spiracles are present on each abdominal segment from 1 to 7 inclusive. The abdomen is terminated by six large spines which in this species lie in two straight rows, with four spines in the dorsal row and two in the ventral row. For a detailed description of a pupa of this genus see Stone (9).

THE PUPAL PERIOD.

The pupal period of *T. lineola* is of short duration. For 201 pupæ on which observations were made, the period varied from 5 to 16 days, the majority requiring from 7 to 9 days (Table III.)

TABLE III.

Tabanus lineola Fabr. Duration of the Pupal Period.
Fayetteville, Arkansas, 1930.

Pupal Period, (Days)	Number of Pupæ	Pupal Period, (Days)	Number of Pupæ
5	2	11	11
6	28	12	3
7	61	13	2
8	35	14	1
9	29	16	1
10	28		

Average pupal period 8 1 days

The duration of the pupal period appears to be influenced by temperature, higher temperatures hastening development. The uniformly high temperatures which prevailed during the summer of 1930 made observations on this point of small value.

Pupæ of this species do not require a drier environment than larvae. In many instances pupæ half submerged in water have developed, and the adults have emerged without difficulty. The greater danger in fact, appears to be that of keeping them too dry. Practically all transformations occurred on the surface of the sand. The adults emerged with ease even though the pupal cases were not partly embedded in the sand, as appears to be true in the natural environment.

Pupæ are difficult to find in the field. A single pupa taken August 22, 1930, in the mud border of a small pond, produced an adult August 28.

THE ADULT.

The adults of *T. lineola* have been taken in the field from May 4 until October 9. They are present in large numbers throughout the season, except for the brief period between generations which occurs in the latter part of July.

During the summer months they begin flying and feeding at about 9:00 A. M. and continue their activities until 6:00 P. M. They appear to prefer cattle as hosts, even when horses or mules are near by. They will occasionally attack a man. When obtaining a meal of blood, several punctures are made, and the pain and annoyance to the host thereby multiplied.

Males are seldom seen in the field. They have been taken occasionally at water, or on flowers.

THE PREOVIPOSITION PERIOD.

A preoviposition period of 9 days was recorded for the only reared fly which fed and oviposited in captivity. This female emerged August 5, at which time it was put in a cage with a male. Both male and female fed greedily on dilute honey provided as food. The female refused to feed on an animal until August 11, when it fed till the abdomen was completely distended. By the following morning the abdomen had resumed its normal proportions. On August 14, which was 9 days after emergence and 3 days after the meal of blood, a normal-sized egg mass was deposited. The mass did not hatch, and remained white, instead of becoming dark grey as all field-collected eggs of this species do. This female refused to feed again after oviposition and died August 29. Mating of this species has never been observed, either in cages or in the field. A second female, treated like the first, emerged July 30, fed on a cow August 11, but deposited no eggs. It died August 25.

OVIPOSITION.

In the insectary oviposition was readily obtained in cages on either rice or barnyard grass. Cylindrical screen wire cages sixteen inches long and eight inches in diameter were used. One end was covered with muslin, and the other rested on the soil in a stone jar. Rice or barnyard grass about twelve inches tall was set in the soil so that it projected up into the cylinder. The soil was kept covered with water to a depth of an inch. Female flies taken in the field during, or soon after feeding were placed in the cages and oviposition usually occurred within a week. No male flies were kept in the cages. Oviposition occurred more frequently when the cages were kept in direct sunlight. A piece of cotton saturated with dilute honey was kept in each cage, and occasionally a fly was seen feeding on the liquid.

Approximately half an hour is required to deposit a complete egg mass containing from 350 to 400 eggs. During the process of oviposition the fly stands head downward and moves forward as successive layers of eggs are placed.

NUMBER OF GENERATIONS.

Eggs have been taken in the field from June 2 until August 14, and they probably occur much later. They have usually been found on low-growing vegetation at the water's edge. No particular plant seems to be preferred as a place for oviposition, and if plants are absent, pieces of wood appear to be quite as acceptable. In the rice-growing section of Arkansas, egg masses of *T. lineola* have frequently been seen on young rice which has just been flooded.

TOTAL DEVELOPMENTAL PERIOD.

The total developmental period as obtained from averages of the egg, larval, pupal, and preoviposition periods is 69.9 days.

It has been generally conceded in the literature that all species of North American Tabanidæ have but one generation a year, and that some require more than a year for complete development. Hine (1) believes that *T. stygius* probably hibernates twice before entering the adult stage. The *T. lasiophthalmus* reared by Hine (1), *T. punctifer* reared by Webb and Wells (10), and *T. atratus* reared by Stone (9), all required one winter of hibernation before the adult emerged.

Tabanus lineola has at least two generations a year in Arkansas. Of the larvæ issuing from four egg masses hatching June 6, 1930, June 23, 1930, July 3, 1930, and July 25, 1930, respectively, all of the 202 larvæ which survived had pupated by September 20, 1930, and the adults had all emerged by September 27. Eggs obtained from one of these flies in a cage were infertile. In the field a second generation would be necessary to carry the species over winter.

Field observations of adult flies and egg masses show that two generations probably occur in Arkansas. A rapid decline in the number of adults and egg masses found in the field occurs during mid-July, after which their numbers again rise and remain fairly constant during the remainder of the season. Adults were first taken May 4, and they increased in abundance until June 21, when they had assumed outbreak proportions in certain localities. During early July their numbers fell until July 18 and 19, on which days not a single fly could be found, and no egg masses were found in the usual places. One fly was taken on July 22, and two were found the following day. From

then on their numbers increased slowly, and egg masses were again found in the places where they had occurred in the spring.

LITERATURE CITED.

1. **Hine, J. S.** 1906. Habits and life histories of Tabanidae. U. S. D. A. Bur. Ent. Tech. Ser. Bul. 12, pp. 19-38.
2. **Hine, J. S.** 1907. Second report upon the horse-flies of Louisiana. La. Agr. Expt. Sta. Bul. 93.
3. **Isaac, P. V.** 1924. Papers on Indian Tabanidae. I, II, III. Mem. Dept. Agr. India, Ent. Ser. VIII, No. 5, pp. 53-62.
4. **King, H. H.** 1914. Notes on the bionomics of *Tabanus taeniola*, and *Tabanus ditaeiniatus*. Bul. Ent. Res. 5: 247-249.
5. **Marchand, Werner.** 1917. Notes on the early stages of Chrysops. (Diptera, Tabanidae.) N. Y. Ent. Soc. Jour. 25: 149-163.
6. **Mitzmain, M. B.** 1913. The biology of *Tabanus striatus* Fabricius, the horsefly of the Philippines. Philippine Jour. Sci. 8: 197-221.
7. **Neave, S. A.** 1915. The Tabanidae of southern Nyasaland, with notes on their life histories. Bul. Ent. Res. 5: 287-320.
8. **Schwardt, H. H.** 1930. Notes on the immature stages of Arkansas Tabanidae. Kansas Ent. Soc. Jour. 4: 1-15
9. **Stone, Alan.** 1930. The bionomics of some Tabanidae (Diptera). Ent. Soc. Amer. Ann. 23: 261-304.
10. **Webb, J. L. and Wells, R. W.** 1924. Horse-flies: biologies and relation to western agriculture. U. S. D. A. Dept. Bul. 1218, pp. 1-36.

BOOK NOTICE.

A HISTORY OF ENTOMOLOGY. By E. O. ESSIG. Pages I-VII and 1-1029, 263 figures and portraits. Published by the Macmillan Company, New York, 1931.

This large volume, thoroughly documented and written in great and painstaking detail has a decidedly Pacific Coast slant as is shown by the chapter headings which are as follows: I. Prehistoric Entomology. II. California Indians in Relation to Entomology. III. Historical Background. IV. Principal Institutions in California Featuring Entomology. V. Historical Facts Concerning * * * * * Orchard Mites and Insects of California. VI. Biological Control of Insects. VII. Insecticides. VIII. Entomological Legislation. IX. Biography. X. A Chronological Table Showing Relation to History and Other Sciences. This is a work that every professional entomologist should own. The great amount of historical detail makes it of value as a reference volume but it is so well written that the first eight chapters completely hold the attention of the reader. Chapter IX, which is a series of over one hundred biographies, is more formally written while Chapter X is a table of events in entomology run in parallel with events in world history and in other sciences. The book is a very distinct and outstanding work.—C. H. K.

THE THERMOPILE FOR TEMPERATURE DETERMINATIONS IN ENTOMOLOGY.

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The thermopile, although used in the same way as described for the simple thermocouple*, has the advantage of producing much greater deflections in the galvanometer. This is a very desirable feature at times, especially when a galvanometer of ordinary low sensitivity is used. The thermopile makes it possible to detect very small changes in temperature or to read accurately to $.01^{\circ}$ or even to $.001^{\circ}$ C., which is practically impossible with the simple thermocouple.

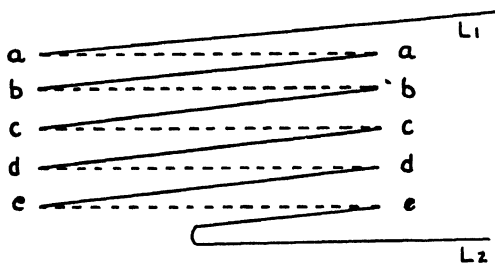


FIG. 1. Arrangement of copper and constantan wires in a thermopile system.

The thermopile is an adaptation of the principle of the thermocouple, and a diagram of its arrangement is shown in Figure No. 1, the full lines representing copper and the broken lines constantan. It will therefore be seen to consist of a number of single couples connected in series. Each single copper-constantan thermocouple develops between 37 and 40 microvolts per degree of temperature difference between its two junctions. Thus, when a number of such couples are connected in series to make a thermopile the total number of microvolts generated will be increased as many times as the number of couples used. The total e.m.f. developed in the thermopile system may, therefore, be comparatively very large depending upon the number of couples.

*The thermocouple method of determining temperature. Ann. Ent. Soc. Am., 20: 513-521; 1927.

The principles of the thermocouple and the potentiometer are described in the previous article referred to; and it is advisable to understand them before proceeding to make and use a thermopile.

CONSTRUCTION OF THE THERMOPILE.

A board is procured about 3 inches greater than the required length of the thermopile, and close to each end a row of small nails is driven in about one-quarter inch apart. There should be 2 nails for each junction plus an extra one at each end for the 2nd lead-in wire. That is, for a thermopile of, say, 10 junctions, 21 nails would be used at each end.

Wire of small diameter such as B. & S. No. 34 gauge is recommended, and double-silk covered insulation is generally preferable, although enamelled wire may have some advantages

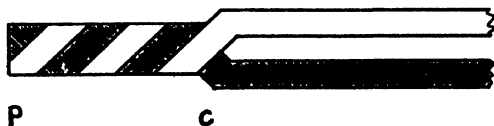


FIG. 2. Spiral connection of wires at junction. Enlarged view.

where the diameter of the bundle of junctions is to be reduced as much as possible. Each odd-numbered nail at one end of the board is connected to the corresponding nail at the other end with a length of copper wire; and each even-numbered nail is connected in a similar manner with constantan. All the wires are then given a coat of shellac to strengthen the insulation and to permit its removal at the tips without fraying. Adequate insulation is important, and at this stage much trouble may be prevented.

When the shellac is dry the wires are fastened down to the board about 6 inches from each end with a strip of adhesive tape. Then with a pair of scissors the wires are cut from the nails.

There are now a number of pairs of copper and constantan wires of equal length lying parallel in preparation for soldering. With a sharp knife the insulation is very carefully removed to expose about 1 inch of metal at each end. This must be done with caution to avoid scraping the metal. Each pair of wires is next connected by twisting together to form a spiral as in

Figure No. 2. The wires must be so joined that a continuous connection of alternate copper and constantan wires is formed with all the junctions in series, as shown in Figure No. 1. These junctions are then soldered, and an electric soldering-iron is preferable as it remains hot while in use. The iron should have a flat surface and upon this some solder is melted. After fluxing, each junction is immersed for an instant in the hot metal which should be deposited in a thin, even covering over the wires.

The points are next cut back to a uniform length of about 2 mm. At this stage it is advisable to test each point to be sure that it constitutes a thermo-electric junction. This is done by connecting to a galvanometer the 2 lead-in wires marked L^1 and L^2 in Figure No. 1, and touching each junction in slow succession with the warm fingers. A deflection indicates that the junction is in effective working condition. This should be done in a room free from sudden changes in temperature, otherwise there may be difficulties in controlling deflections due to variations in temperature of the 2 ends of the thermopile. A good plan is to make up each end of the thermopile into a temporary bundle but bending each junction away from the others so that none are touching. Then place one end in a wide test tube while testing the other end. Precaution should be taken when testing to avoid breathing upon the junctions.

It is important to make each point or junction, shown in Figure No. 2, as short as is consistent with strength. Also when making a determination the points should always be inserted well into the material, otherwise a difference in temperature may exist between C and P and set up secondary thermocouples.

The next step is one that requires especial care, namely, the complete insulating of the exposed metal of each junction. Unless this is done most thoroughly the thermopile will not be satisfactory. For this purpose collodion has been found to give excellent results. Each junction is dipped into collodion well below the exposed metal and allowed to dry thoroughly. A second coat is advisable and a third may be necessary to ensure a complete covering.

After thorough drying for several hours, the junctions at each end are made up into a permanent bundle. The points should all have outside positions. This can be done by placing

2 or 3 points at the tip and arranging the others closely together around the sides as in Figure No. 3-a. An effort should be made to reduce the diameter of the warm-junction bundle if it is to be inserted into a small space.

Several methods of finishing the thermopile are available. It may be enclosed in glass tubing, which has some advantages but is too rigid for most purposes in entomology. A satisfactory enclosure can be made with rubber tubing. This does not interfere with flexibility and gives sufficient protection from injury and short circuits. If a momentary lag in temperature determination is permissible, thin glass tubing, sealed at one end, may be used to enclose the bundle of junctions at the "warm" end, as shown in Figure No. 3-b. The bundle is

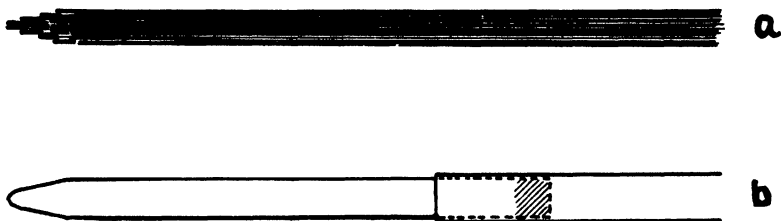


FIG. 3. Arrangement of junctions in bundle; and glass container.
Enlarged view.

first dipped in melted paraffin and, while the wax is still soft, is pressed to the tip of the glass tube. This will exclude air and greatly reduce lag. The bore of the tube should be as small as possible. If instantaneous readings are essential the warm junctions should not be enclosed in glass but dipped several times in shellac or other suitable material to protect the collodion insulation. This outer covering should not, of course, be soluble in ether as it would tend to injure the collodion insulation.

The bundle of cold junctions, to be placed in the thermos bottle, should be enclosed in a length of glass tubing sealed at one end, and allowed to rest in the icewater 2 or 3 inches. A convenient exit for the lead-in wires is between the glass and rubber tubing at the cold junction end.

The connection of the thermopile with the potentiometer is similar to that for the simple thermocouple, and is shown

in Figure No. 4. The bundle of junctions at A is the "warm" end and is to be placed in contact with the material of unknown temperature. The "cold" junctions at B are placed in the thermos bottle T. The lead-in wires L^1 and L^2 are connected to the proper binding posts on the potentiometer P. The galvanometer G is used in obtaining the null point.

MAINTENANCE OF THE "COLD JUNCTION" TEMPERATURE.

The temperature indicated by the thermocouple or thermopile is the difference between the temperatures of the thermo-

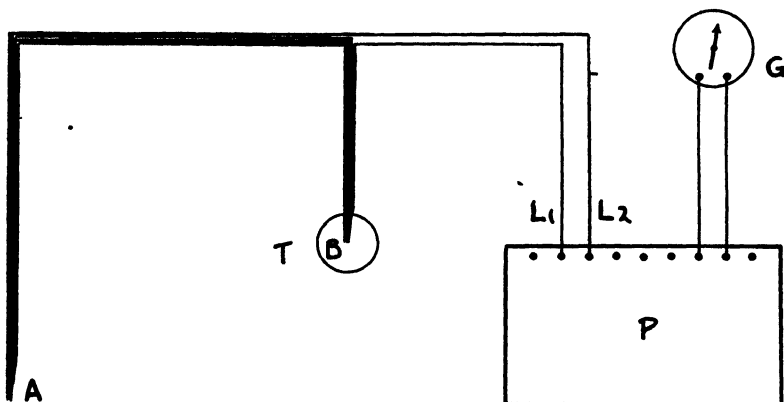


FIG. 4. Showing connections of thermopile with potentiometer and galvanometer.

electric junctions at A and B, Figure No. 4. One of these temperatures, that at B, is required to be known; and the dependability of the couple as a precision instrument can be no greater than the accuracy with which the cold junction temperature is known. The simplest way to satisfy this requirement is to maintain that temperature uniformly constant.

Fortunately a constant temperature can easily be obtained in a suitable mixture of ice and water in a thermos bottle. The bottle should be made up with as much chipped ice from distilled water as it will hold and then be filled up with cold, distilled water. Such a mixture will maintain for hours a temperature in the upper part of the bottle which will not fluctuate from zero more than $.001^\circ$ to $.002^\circ$. This uniformity

cannot be depended upon unless the thermos bottle is well filled with chipped ice. A bottle half-filled with ice and the remainder with water would produce a temperature gradient as seen in Figure No. 5. This chart shows that the required temperature of zero is obtained only in the upper 2 to 3 inches, below which the temperature is continuously changing. A cold junction resting below the 3 inch level would cause large errors in readings.

When determinations are to be made over long periods of time it is advisable to insert a precision or a Beckmann ther-

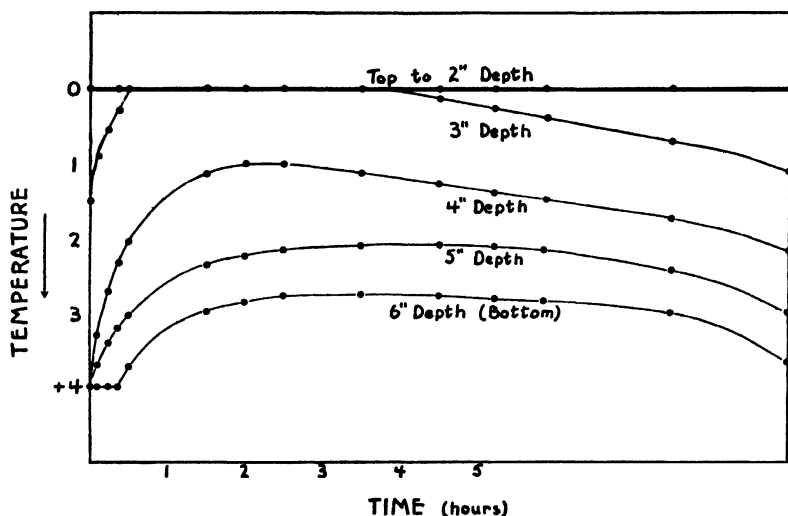


FIG. 5. Showing variations from 0° C. of ice and water in a thermos bottle if insufficient ice is used.

mometer in the cork at the cold junction end, and note when the temperature begins to rise. Both the thermometer and the tube containing the junctions should rest, of course, at the same level in the ice-water.

CALIBRATION.

The number of microvolts which the thermopile will generate per degree of temperature difference now remains to be determined. This value is obtained through the potentiometer. The cold junction is placed in the thermos bottle and the pile is

connected to the potentiometer. The warm junction is next exposed successively to 3 or 4 known temperatures. The number of microvolts generated at each temperature is divided by the number of degrees of temperature between the cold and warm junctions. The results should be practically a constant for all temperatures with which entomologists are concerned. The accuracy with which these various temperatures should be known will depend upon the precision required. If an accuracy in reading within $\frac{1}{2}^{\circ}$ or less is satisfactory the pile may be calibrated by the use of water baths, the water being stirred and the thermometer accurate to that extent.

For precision work, temperatures such as transition and melting points are used. The following are suggested:

1. Transition point of manganous chloride..... 58.08° C.
- 2.. Transition point of sodium sulphate..... 32.38
3. Melting point of ice in distilled water..... 0.0

The transition points are easily obtained. For instance, with sodium sulphate, about 20 grams of anhydrous crystals are placed in a clean, wide test tube and moistened with distilled water. The temperature of the mass will then rise to 32.38° C. The warm junctions should be pushed well in, and when the temperature ceases to rise and remains constant for a time the number of microvolts generated should be noted. That value divided by 32.38 will give the number sought.

In all subsequent work, for assurance that the thermopile and its accessory apparatus are in reliable working condition, a daily check-up with some known temperature is recommended.

HOW TO APPLY THE CONSTANT OBTAINED BY CALIBRATION.

Having determined the number of microvolts, C, which the thermopile will generate per degree of temperature difference, any unknown temperature may be read by dividing the number of microvolts generated by the constant C. The value for C will be reliable to about 0.01° through the range of temperatures used in calibration and probably for all temperatures in which entomologists are interested.

IMPORTANCE OF THE SEX RATIO IN ORIENTAL FRUIT MOTH PARASITE BREEDING.*

PHILIP GARMAN AND J. C. SCHREAD.

Parasite breeding under artificial conditions is beset with many pitfalls in which the unwary may come to grief. Among those worth mentioning are the maintenance of host material in sufficient numbers, the provision of suitable quarters for the parasites to work, and finally the provision of parasites and hosts in a continuous succession, as well as the maintenance of an ever increasing parasite population so that some may be laid aside for distribution or liberation. In connection with

TABLE I.

Per Cent of Males of *Macrocentrus ancylivora* Roh. Reared at Different Times under Different Conditions.

SOURCE OF PARASITE MATERIAL	TOTAL PARASITES	PER CENT MALES
Collected in New Jersey in June and July.....	9,590	41.0
Reared in:		
July—Insectary.....	1,936	48.6
August—Insectary.....	1,063	68.5
September—Greenhouse.....	686	69.2
October—Greenhouse.....	1,599	69.5
November 1-10—Greenhouse.....	138	68.8
November 11-30—Greenhouse.....	142	53.1

the latter problem it has become increasingly apparent that the sex ratio of the parasite is one of the limiting factors in maintaining a sufficient increase to keep ahead of the game. It has generally been accepted that the ratio of males and females is constant, a few writers, however, indicating the effects of temperature on the ratio. The data which we present herewith bear upon this problem in showing that it is an easily variable ratio, affected strongly by refrigeration in the case of *Trichogramma*, Table II, and possibly by several factors for *Macrocentrus*. It will be seen that the percentage of male *Trichogramma* emerging after 12 days refrigeration was 25 per

*Contribution from the Com. Agr. Exp. Station, 1931.

cent, whereas the percentage was 75 after 50 days. In the case of *Macrocentrus* (Table I) it will be seen that the percentage of males varies all the way from 41 per cent for material imported from New Jersey to 69 per cent for parasites reared in September under greenhouse conditions.

It has been our experience that *Trichogramma* quickly come back to a low percentage of males, which is indicated by the last two items in Table II, the results of continuous generations

TABLE II
Effect of Refrigeration on Percentage of Male
Trichogramma minutum Riley †

EXPOSURE IN REFRIGERATOR AT 38-40° F, DAYS	PER CENT OF EGGS HATCHED	PER CENT MALES EMERGING	NOTES
12	67	25	
23	46	34	
24	20	40	
26	40	61	
28	51	52	
33	46	67	
41	20	66	
43	19	66	
44	23	66	
45	12	76	
50	17	76	
54	6	69	
62	2	77	
None	94	33	Continuous rearing with- out intervening refrig- eration
None	92	25	

†Reared in eggs of *Sitotroga cerealella* Oliv

after removal from the refrigerator. Normally it requires three to four generations for *Trichogramma* to regain their usual reproductive power after long exposure to cold.

In the case of *Macrocentrus* it is not difficult to figure mathematically the difference in the rate of increase for those with high and low percentages of males. Thus if we start with an initial number of 10 adult parasites of which seven are males, (allowing six eggs for each female and assuming a constant ratio as occurred from August to October) in four generations there will be 102 adults of which 30 are females. If, on the other hand, the ratio of males to females is equal, there will result in four generations 710 adults, of which 355

are females, or, if the ratio of males is still lower, approximately two-fifths of the whole as occurred with the *Macrocentrus* collected from New Jersey, there will be 1675 adults, or 1005 females, at the end of the fourth generation. Thus instead of 30 female parasites after four months (average life cycle 28 days, preoviposition period, three days) the operator would theoretically at least have more than 30 times as many. While this difference is not always attainable in breeding work, the importance of this factor cannot be ignored and should, we believe, be carefully considered in the mass production of any parasite. It likewise seems probable that there is considerable fluctuation in the normal ratio in the field for if a change of ratio is so easily produced, there must be a considerable difference in different localities and climates, which may even affect abundance or natural distribution.

BOOK NOTICE

DEMONS OF THE DUST. By WILLIAM MORTON WHEELER, W. W. Norton & Company, Inc., Publishers, New York.

This book is not, as might be imagined from the title, a tale of bull fights in Mexico, or cowboy adventures on the plains, nor even of auto racers on the sands of Daytona beach. However the title will be found quite fitting as Doctor Wheeler has brought together in this book a very interesting collection of studies upon certain groups of insects which have developed diabolical habits in securing their food.

There is an interesting chapter on "Some Eighteenth Century Naturalists," treating of certain writers who presented the results of their studies of these insects; a chapter on "The Fauna of the Sands," giving a general survey of adaptation to arid conditions, then a series of chapters reviewing studies of different dust or sand inhabiting species with a quite complete monograph of the genus *Lampromyia*. Appendices include translations of early papers by De Geer and Reaumur. There is an extended and very complete bibliography.

This book is written in Doctor Wheeler's very interesting style and the illustrations and descriptions are evidently of his usual exact and illuminating portraiture. The book will appeal to a wide circle of readers, both on account of its entertaining style and the remarkable habits of the insects treated. To students of entomology it offers both a comprehensive discussion of certain insects and a model of presentation for complex biological phenomena.—H. O.

NEW ASILIDÆ, WITH A REVISED KEY TO THE GENUS STENOPOGON LOEW: (DIPTERA).

STANLEY W. BROMLEY,
Bartlett Tree Research Laboratories,
Stamford, Connecticut.

The species dealt with in the present paper were in the collection of the late Professor James S. Hine, of the Ohio State Museum, Columbus, Ohio. In several instances the specimens had been set apart, evidently for description in the future. Unfortunately death intervened and this desired result was not obtained. It has been a privilege accorded me to study the remarkable collection which Professor Hine left and the present notes are the results of a preliminary survey of this collection.

The types of the new species are in the Hine Collection. Ten species, representing three subfamilies, are described.

DASYPOGONINÆ.

The genus *Stenopogon* Loew has been treated by Back in his excellent work on the Robberflies of America, North of Mexico, belonging to the Subfamilies Leptogastrinæ and Dasypogoninæ (Transactions of the American Entomological Society, XXXV, 1909, pages 137-400, 11 plates). This key is herewith presented in a revised form to accommodate the new species described.

KEY TO STENOPOGON LOEW.

- | | |
|--|------------------------------|
| 1. Katapleurotergite ("Hypopleura") bare | 2 |
| Katapleurotergite ("Hypopleura") with hair or bristles (<i>Scleropogon</i>).... | 13 |
| 2. Third segment of antenna somewhat oval, arista short and bristle-like,
wings short and narrow | 3 |
| Third segment slender, arista not so sharply differentiated, wings longer
and broader | 5 |
| 3. Species 15-19 mm. in length, vestiture of thoracic dorsum yellowish,
posterior portion unusually bristly | <i>breviusculus</i> Loew. |
| Small, slender species (10-13 mm. in length), vestiture finer and more
scanty | 4 |
| 4. Black species | <i>nigritulus</i> Coquillett |
| Yellowish-brown species | <i>albibasis</i> Bigot |
| 5. Sternopleura with a tuft of long fine pile | 6 |
| Sternopleura without such a tuft, although usually with some pile | 12 |
| 6. Mystax black | <i>jubatus</i> Coquillett |
| Mystax lighter-colored | 7 |

7. Abdomen black, at least first five segments..... 8
Abdomen with varying amounts of reddish on these segments..... 10
8. Reddish pollinose, vestiture of head mostly reddish-yellow. *rufibarbis* n. sp. 9
Grayish-yellow pollinose, vestiture of head straw-colored. 9
9. Robust species, base of abdomen and thorax rather thickly straw-yellow pilose. *felis* n. sp.
Less robust species; base of abdomen and thorax not as thickly pilose, *obscuriventris* Loew.
10. Robust, reddish-haired in male; female with vestiture more straw-colored; abdomen partly reddish above, sides broadly black. *gratus* Loew
11. More slender, vestiture straw-colored; abdomen mostly reddish, sides narrowly black. *californiae* Walker
12. Large variable species (20-37 mm.) with varying amounts of red on abdomen. *inquinatus* Loew
(= *modestus* Loew)
(= *morosus* Loew)
13. Third segment of antennae elongate, style usually short, sometimes longer and more slender, first posterior cell generally open. 14
Third antennal segment more oval, style bristle-like; first posterior cell more frequently closed. 21
14. Decidedly black, with or without red on abdomen; the latter not obscured by a grayish bloom; wings black. 15
Reddish; or if black, with abdomen obscured by bloom; wings reddish or brownish 16
15. Abdomen wholly polished black. *nitens* Coquillett
Abdomen, except base and tip, reddish. *aecidinus* Williston
16. Southeastern species; reddish-yellow, abdomen long and quite slender, wings broad, dark brownish. *subulatus* Wied.
Western species. 17
17. Abdomen unusually long; wings long and narrow, yellowish-gray; (abdomen, except back and sides, reddish). *longulus* Loew
Abdomen less elongate, wings shorter and usually broader. 18
18. Blackish, covered uniformly with grayish bloom. *pumilus* Coquillett
Reddish (abdomen at least). 19
19. Wings brownish with considerable reddish toward base. 20
Wings darker, no reddish; large, robust species (22 mm.) (Texas), *tenebrosus* Coquillett
20. Thorax grayish pruinose; bristles whitish. *consanguineus* Loew
Thorax yellowish pruinose; larger and more robust; wings broader, femora stouter; bristles of body more golden, (Texas). *latipennis* Loew
21. First posterior cell closed. 22
First posterior cell open. 25
22. Wholly and densely grayish white pruinose, wings hyaline; small (15 mm.) slender species. *cinerascens* Back
Not completely and densely whitish pruinose. 23
23. Large species (20-28 mm.). 24
Smaller species (15-19 mm.); thorax grayish-yellow pollinose, contrasting with abdomen which is gray pollinose. *coyote* n. sp.
24. Chamois-leather yellow, abdomen long and slender, without black fasciae. *helvolus* Loew
Yellowish-gray pruinose, abdominal segments black with posterior margins and venter red. *picticornis* Loew
25. Reddish species with black margins on thorax; wings blackish with reddish toward base. *texanus* n. sp.
Black species, grayish pollinose; wings hyaline. *neglectus* n. sp.

***Stenopogon coyote*, new species.**

Total length, 15–19 mm. Resembles a miniature *S. helvolus* Loew. The hypopleura bear fine hairs, the arista is bristle-like, the first posterior cell is closed as in *helvolus*, but the ground color of the body is black. The pollen of the abdomen is more grayish than that of the thorax where it is grayish-yellow, making a slight contrast between the color appearance of the two regions.

Male.—Proboscis and palpi dark reddish-brown; 1st 2 antennal segments reddish-yellow, third and arista black. Vestiture of head straw-yellow, darkest on vertex; the beard lightest. Thorax black, covered with a grayish-yellow bloom, vestiture straw-yellow. Humeri and a small area just beneath reddish. Wings hyaline, short as in *helvolus*. Legs reddish, femora black above. Hind tibiæ darker than others. Hairs and bristles of legs straw-colored. Abdomen black, grayish pollinose, and covered with fine straw-colored hairs. There is a suggestion of reddish at the incisures and the genitalia are reddish.

Female.—Similar, the ovipositor with dark reddish-brown bristles.

Holotype, ♂, near Lander, Wyoming, 5000–8000 feet, July (Roy Moodie). *Allotopotype*, ♀, same data. *Paratopotype*, ♀. *Paratypes*, ♂♂ (2), 40 miles north of Lusk, Wyoming, July, 1895; Salida, Colorado, July 16, 1898; Poncha Springs, Colorado, July 13, 1898. ♀♀ (4) 40 miles north of Lusk, Wyoming, July, 1895; Las Cruces, New Mexico, May (Cockerell); Garden of the Gods, Colorado City, Colorado, July, (E. S. Tucker); Flagstaff, Arizona, June 4; Salida, Colorado, July 16, 1898; Poncha Springs, Colorado, July 7, 1898.

The venter of the abdomen varies from reddish to black. This seems to be a common species in collections and one frequently identified as *S. helvolus* Loew. It is however definitely distinct from that species.

***Stenopogon felis*, new species.**

Total length, 22–24 mm. Similar to *S. obscuriventris* Loew., but differs in having the abdomen more thickly pilose toward the base, all the tibiæ being blackish toward the tip, and in being somewhat more robust in general appearance.

Male.—Black; vestiture of head pale yellowish, the beard and palpal hairs lighter. A few black hairs on vertex. Head and thorax grayish-yellow pollinose. Hairs and bristles of mesonotum pale yellow, black hairs along median line. Pleural and coxal hairs and hairs and bristles of legs pale yellow. Basal $\frac{1}{4}$ ths of femora, tips of tibiæ and tips of tarsomeres of posterior tarsi black, rest of legs reddish-yellow. Wings pale brownish, anal angle milky-white, base of veins reddish. Halteres pale brown. Abdomen shining black, incisures dark brown;

thickly covered with fine golden pile which is longer and thicker toward the base. Genitalia black with golden hair.

Female.—Similar, but without milky-white anal angles of the wings. Spines of ovipositor dark reddish.

Holotype, ♂, Coronado, California. June 22, 1890. (F. E. Blaisdell). *Allotopotype*, ♀, same data.

***Stenopogon neglectus*, new species**

Total length, 19-28 mm. A black species, dark gray pollinose, related to *Stenopogon* (*Scleropogon*) *helvolus* Loew, but differing in having the first posterior cell open, and in being black in ground color with a dark grayish bloom, instead of chamois-yellow with a grayish-yellow bloom. The incisures of the abdomen are brownish. Antennal style bristle-like. "Hypopleura" with fine hair.

Male.—Antennæ, proboscis and palpi black. Face and occiput silvery pruinose. Vestiture of beard very pale straw-colored, beard nearly white. Thorax black, except the humeri, a small area just beneath humeri, and areas along the sutures of the pleura, which are reddish. Front coxæ black, others reddish with black areas anteriorly. Thoracic vestiture straw-colored, except fine hairs on mesonotum which are black. Thorax with grayish bloom. Legs with straw-colored bristles and hairs. Middle and posterior femora black above, reddish-below. Tibiæ light reddish-brown, the hind almost black. Tarsi light reddish brown. Wings short as in *helvolus*, nearly hyaline, first posterior cell open. Abdomen black, gray pollinose, with fine straw-colored hairs. Venter and margins of segments pale reddish-brown. Genitalia reddish-brown below, blackish above.

Female.—Similar; margins of abdominal segments more narrowly reddish. A reddish dorsal line on segments 7 and 8. Spines of ovipositor reddish.

Holotype, ♂, near Lander, Wyoming, 5000-8000 feet, August (Roy Moodie). *Allotopotype*, ♀, same data. *Paratopotypes*, 5 ♂♂; ♀♀ 2. *Paratypes*, ♂♂ (4), Lewiston, Idaho; (2) Creeds, Colorado, 8844 feet, August, 1914 (S. J. Hunter); Yellowstone Park, July 25, 1923, Roaring Mountain [elevation, 7500 feet] (H. C. Severin); ♀♀, Lewiston, Idaho; Creeds, Colorado, 8844 feet, August 14 (S. J. Hunter); Castle, Oregon, September 2, 1923 (Carl Duncan); Ac. SL. Dsrt, Utah, July 24, 1925 (Hall).

The width of the reddish margins on the abdominal segments varies considerably as does the color of the venter; in some the venter is darker, almost black. In one anomalous specimen the first posterior cell is closed in one wing and open in the other. In some of the males, the genitalia are entirely black.

***Stenopogon rufibarbis*, new species.**

Total length, 20–23 mm. Related to *obscuriventris* Loew, from which it may be distinguished by the brighter, more reddish color of the legs, the vestiture of the head and abdomen, the pollen of the thorax; and to *gratus* Loew from which it may be separated by the uniform color of the hind tibiæ, lacking the darkened apex of *gratus*, and the absence of red areas on the dorsum of the abdomen.

Male.—Black. Vestiture of head light reddish, except hairs on vertex which are black. Head and thorax brassy-yellow pollinose, inclined to reddish on thorax. Mesonotum with black hairs, the posterior portion and the scutellum with reddish bristles. Pronotum and pleura with pale reddish hairs. Wings tinged with brownish, the anal angles milky-white. Bases of veins reddish. Halteres pale reddish. Coxæ and legs with reddish hairs and bristles. Tarsi, tibiæ and distal fifth of femora reddish; rest of femora black. Abdomen shining black with pale reddish or golden pile. Genitalia reddish.

Female.—Similar, but with the wings uniformly brownish, the first 5 segments of abdomen grayish brown pollinose, the succeeding shining black; 7th tergite reddish.

Holotype, ♂, Lassen Co., California, July 20, 1911. *Allotype*, ♀, San Antonio Canyon, Ontario, California, July 25, 1907. *Paratypes*, ♂♂ (3) Lassen Co., California, July 20, 1911; ♀♀ (3) Lassen Co., California, July 20, 1911; Los Angeles Co., California, 1200 feet, near Pasadena, May 5, 1910 (F. Grinnel, Jr.); "Cala." (no other data).

Some of the males have the genitalia blackish, and some of the females have the 7th tergite in addition to the 8th reddish, but none have the reddish areas on the preceding segments as occurs in *gratus* Loew and *californiæ* Walker.

***Stenopogon texanus*, new species.**

Total length, 18–23 mm. A handsome reddish species with wings reddish towards base and along anterior margin, brownish elsewhere; black markings on the mesonotum; the hypopleura with fine hair, the style of antennæ short and the first posterior cell open.

Male.—Reddish. Head black, the face grayish-white pollinose, the occiput golden pollinose. Antennæ reddish with black bristles; proboscis black, mystax, palpal hairs and beard pale yellowish-white. Occipital bristles golden; hairs of vertex black. Prothoracic bristles pale reddish. Thorax red; pleura and coxæ partly blackish. The mesonotum bears three black lines, the median narrowly bisected longitudinally, with a golden streak of pollen. Sides of mesonotum also golden pollinose. Hairs and bristles of mesonotum black, except those of humeral callus which are reddish. Pleura and coxæ with pale golden hairs. Legs reddish with concolorous hairs and black

bristles. Middle and posterior femora with a black line on upper surface, front femora with a black streak anteriorly and another posteriorly. Many fine hairs on the dark streaks black. Wings brownish toward tips, bases and anterior margin reddish. Scutellum reddish with a black spot at base; bristles black. Halteres pale yellowish-brown. Abdomen reddish, blackish at ends, the dark areas covered with grayish bloom; with fine scattered reddish hairs. Genitalia reddish with black hairs. Venter reddish.

Female.—Similar, but with some pale bristles in posterior part of mesonotum. Abdomen darker towards tip.

Holotype, ♂, Dilley, Texas, May 6, 1920 (H. J. Reinhard). *Allotopotype*, ♀, May 5, 1920 (H. J. Reinhard). *Paratypes*, ♂, Marble Falls, Texas, April 4, 1923 (C. A. Harned); ♀ ♀, Marble Falls, Texas, April 21, 1923 (C. A. Harned); Christoval, Texas, April 27, 1915 (A. K. Fisher).

***Heteropogon rubrifasciatus*, new species.**

Total length, 10–15 mm. A black species related to *macerinus* Walker, but differing in having the posterior margins of abdominal segments 2–6 reddish and 7th segment entirely so. The middle tibiae in the male lack the brush of black hairs and bristles characteristic of *macerinus*.

Male.—Head pilose and bristles, the vestiture whitish, except the following which are black; a few bristles on antennae, vertex and occiput and the palpal hairs. Antennae and proboscis dark brown. Thorax grayish pollinose, with three broad blackish stripes on the mesonotum. Hairs on notum mostly black, but the thick pile on the pronotum and pleura is whitish. Some of the bristles on the posterior portion of the mesonotum and on the scutellum are white. Legs dark reddish brown with black bristles and fine white hairs. Wings very faintly tinged with brown, slightly darker along the anterior portion of the apical half. The wings are noticeably clearer than those of *macerinus* Walker. Halteres reddish brown.

Abdomen black with pale yellowish-white pile. Posterior margins of segments 2–6, broadly reddish, the sixth mostly and the 7th entirely red. There is a whitish spot on the posterior lateral margins of segments 1–4. Genitalia reddish, the bases of the upper forceps dark reddish-brown.

Female.—Similar, but with wings slightly darker. Segments 5 and 6 are mostly reddish above, blackish at sides, while the following are black. Spines on ovipositor black.

Holotype, ♂, Southern Pines, N. C., September 12, 1912 (A. H. Mennee) (No. 11). *Allotopotype*, ♀, same data, No. 12. *Paratopotypes*, ♂, September 12, 1912 (A. H. Mannee). (Note by H. S. Harbeck, “*Heteropogon* near *gibbus*, probably new”);

♀ ♀, September 3, 1912; September 28, 1915; September 28, 1915 (label, "Preys from tips of dead twigs"). All collected by A. H. Mannee and in the J. S. Hine collection.

***Deromyia neoternata*, new species.**

Total length 18–29 mm. A pale reddish species with three velvety black stripes on the mesonotum; the abdomen without black spots on the sides of the segments, coarctate, the constriction coming between the second and third segments. This species has been hitherto known as *ternata* Loew, a Cuban species which differs in several respects as I pointed out in the *Asilidæ* of Cuba (Annals Ent. Soc. Amer. Vol. XXII (1929) p. 278.) *Neoternata* differs from *ternata* as follows: it is proportionately less robust, the pollen on the thorax is less decidedly golden, the median line on the mesonotum fades into reddish anteriorly, and there is no blackish area above the second and third coxæ.

Holotype, ♂, Russell Co., Kansas, 1830 feet, August 26, 1912. (Coll. F. X. Williams). *Allotype*, ♀, Osborne Co., Kansas, 1557 feet, August 3, 1912 (F. X. Williams).

I have examined numerous specimens from Florida to Colorado and from Indiana to Texas. I have collected the species in Missouri, South Carolina, and Indiana. It occurs mostly where the herbage is rank at the edge of low fields or woods and many of the specimens I have collected were noted in and around blackberry or raspberry thickets.

LAPHRIINÆ.

***Laphria stygia*, new species.**

Total length 25–27 mm. A large black species with small whitish pruinose spots on the posterior lateral margins of abdominal segments 2–4, inclusive. The wings are black and there are bluish or purplish reflections on the thorax and abdomen.

Female.—Head black; vestiture coarse, black; a very small tuft of whitish hairs under the eyes and a few minute scattered white hairs on the face. Face, vertex (except ocellar tubercle), and occiput near margin of eyes thinly brownish pollinose. Thorax black with black hairs and bristles. Ground color of mesonotum deep metallic blue. Hairs and stiff marginal bristles of scutellum black. Pleura light brown pollinose, becoming almost silvery near coxæ. Wings black or very dark brown, the interior of some of the larger cells paler. Halteres light brown. Legs and abdomen black with deep metallic bluish reflections. Hairs and bristles, stout, black. The posterior lateral margins of segments 2–4 (inclusive) whitish pollinose. Ovipositor short as in *Laphria*, with a few long black bristles.

Holotype, ♀, Stovall, North Carolina, June 26, 1919, (J. A. Eckert). *Paratypes*, ♀ ♀, Ovet, Mississippi, June 20, 1914 (J. W. Hathaway); June, 1916, Locality (?).

This species would fall in the genus *Laphria* if the old definition were adhered to. The proboscis is, however, of an entirely different type from the typical *Laphria*, but approaches that of *Panamasilus* Curran. The species appears to be confined to Southeastern United States and is undoubtedly very rare. It superficially resembles *Pogonosoma dorsatum* vr. *melanopterum* Wied., but a comparison of the two shows them to be entirely unrelated.

***Bombomina engelhardti*, new species**

Total length 17-23 mm. A yellow pilose species, with the scutellum and first segment of the abdomen with black hairs and bristles. There is considerable reddish pile mingled with the yellow pile on the abdomen. Related to *B. fernaldi* Back, from which it may be distinguished by the even distribution of the red hair on the abdomen, not restricted to certain areas as in *fernaldi*, and the first segment of the abdomen being always black-haired in contrast to the second which is thickly yellow pilose.

Male.—Head black, yellow pilose, except hairs of upper part of occiput, and a few hairs in lower part of mystax, beard, and on palpi which are black. Pronotum with black bristles. Mesonotum thickly dark yellow pilose. A yellow tuft of hairs in front of wings and in front of halteres. Coxæ yellow-haired; considerable black on posterior pair. Legs black with black hairs, except the hairs on posterior aspect of front femora, the dorsal aspect of the first and second pair of tibiae, and a few hairs on the dorsal aspect of the basal portion of the hind tibiae, which are yellow. Wings and halteres light brownish. Scutellum and first segment of abdomen with black hairs and bristles. Segments 2-6 above densely yellow pilose with reddish hairs uniformly intermingled. Genitalia black or with some black and some pale hairs and bristles.

Female.—Similar, except black hairs predominate in beard and on coxæ. The apex of the abdomen from the 7th segment on is black-haired, with a few yellowish hairs on ovipositor.

Holotype, ♂, S. W. Colorado, July 15, 1898. *Allotype*, ♀, Jemez Springs, New Mexico, May 24, 1913 (John Woodgate). *Paratypes*, ♂ ♂ (6) Jemez Springs Mountains, New Mexico; (2) Oak Creek Canyon, Arizona, 6000 feet, August (F. H. Snow); "Colo." ♀ ♀ (3) Jemez Springs Mountains, New Mexico; S. Arizona (F. H. Snow), August, 1902. S. Franc Mountain, Arizona, July 15 and July 14, 1892; Durango, Colorado, June 14, 1889.

Named in honor of Mr. G. P. Engelhardt, who collected this species in New Mexico.

ASILINÆ.

Promachus hinei, new species.

Total length, 30-35 mm. Closely related to *Promachus rufipes* Fabr. from which it may be distinguished by the femora being reddish instead of black, the light pollen of the abdomen grayish or grayish yellow instead of yellow; the thorax deeper reddish brown, and the pale pile of the head thorax and abdomen grayish instead of yellow.

This is the species referred to by Hine, (Annals Ent. Soc. America, Vol. IV, (1911), p. 166,) under *Promachus rufipes* Fabricius. *P. rufipes* Fabricius occurs for the most part east of the Alleghanies, while *hinei* n. sp. occurs west of the Alleghanies from Ohio to Texas and Missouri. The specimen figured under the name *vertebratus* in Howard's Insect Book, Plate XVIII, Fig. 8, is *hinei*. Both *rufipes* and *hinei* occur in Ohio.

Holotype, ♂, West Jefferson, Ohio, August 26, 1923. *Allotopotype*, ♀, same data. *Paratypes*, ♂♂, Georgesville, Ohio, September 10, 1898; Posey Co., Indiana, August 10, 1924; Benoit, Mississippi, July 18, 1899; Henry County, Iowa, August 25, 1904; C. T. Vorhies; ♀♀, Oxford, Ohio, Coll. W. H. S.; Victoria, Texas, August 1, 1925. R. H. Painter Coll., another same data with a Megachilid bee as prey; Geneva, Indiana, August 6, 1911 (E. B. Williamson Coll.) with an Andrenid bee as prey.

Named in honor of the late Professor James S. Hine, who had worked extensively on the North American species of this genus of *Asilidæ*.

NOTES ON THE BIOLOGY OF THE STABLE-FLY, *STOMOXYS CALCITRANS* LINN.

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A review of the literature pertaining to the Stable-fly, *Stomoxys calcitrans* Linn., revealed the fact that our knowledge of the life history of this important stock pest under constant temperature and humidity conditions was far from complete. In the course of an investigation which necessitated the rearing of large numbers of *S. calcitrans*., a few notes on the life history of this insect were made which seem worthy of a brief presentation.

Incubation Period. At 20 minute intervals eggs were removed from test tubes containing gravid female *S. calcitrans*, and placed on wetted toweling paper in small ground glass top stender dishes. The stender dishes were then placed in constant temperature ovens. When hatching commenced, the larvæ were removed and the number recorded at 20 minute intervals. The results of these studies were as follows:

Temperature, °C.	Number of Observations	Range	Mean Time in Hours
25.....	1169	32.5-35.2	33.4
30.....	1264	25.0-28.5	26.5

Larval and Pupal Period. The length of the larval period was determined indirectly, e. g.: The larval and pupal periods were determined together and then the pupal period was determined separately. For rearing the larvæ two types of containers were employed, namely: 2-oz., wide-mouth bottles for groups of 10 larvæ, and battery jars, 15.5 cm. in diameter and 20.5 cm. high, for groups of 100 larvæ.

Newly hatched larvæ were placed upon the breeding media (See Table. I) and observations made every two hours during time of emergence. Table I shows the results of these tests.

Numerous rather unsuccessful attempts were made to rear *S. calcitrans* on both clean wheat straw that had been wetted down for 1, 2, 5, 10, and 20 days, before the larvæ were placed

TABLE I.

Showing Effects of Food and Temperature on Length of Larval and Pupal Periods of *S. calcitrans*.

Temp. °C.	Container	Breeding Media	No. Obser- vations	Hour Range	Mean Time in Hours
25	2-oz. bottles...	Wheat bran and alfalfa meal, half and half by weight.....	278	351-406	377
25	Battery jar....	Wheat bran and alfalfa meal, half and half, by weight.....	81	337-409	372.6
30	2-oz. bottles...	Wheat bran and alfalfa meal, half and half, by weight.....	798	293-349	311.7
30	Battery jar....	Ground oats.....	178	304-344	320.2
30*	Battery jar....	Ground oats.....	303	297-347	326.1

*Results of preliminary test made during summer of 1929.

TABLE II.

Showing Effect of Various Relative Humidities on the Per Cent Emergence and Length of Pupal Stage of *Stomoxys calcitrans* Linn, at 25° C.

Salt	Approx. Per Cent R. H.	Number Pupa Started	Per Cent Adults	Length of Pupal Period	
				Range	Mean Time in Hours
H ² O.....	100	575	99.8	168-192	177.2
NaCl.....	78	100	.10	140-189	164.6
KC ² H ³ O ³	19	50	0	.....	.....
H ² SO ⁴ Conct....	0	200	0	.....	.....

thereon and clean wheat straw which had been steam cooked at 90° C. under about ten pounds pressure for 1, 2, 4, 12, and 24 hours. The per cent emergence was less than 10 in all

of the above mentioned cases, and the individuals appeared to be invariably smaller than those reared from ground oats or wheat bran and alfalfa meal.

Pupal Period. Newly formed white pupa were removed from the breeding media and placed at constant temperature and constant relative humidities. Observations were made every two hours during time of emergence. Table II shows the results of these tests.

SUMMARY.

From the data presented above the following conclusions are drawn:

- I. Incubation period of *S. calcitrans* at 25° C. is 33.4 hours; at 30° C., 26.5 hours.
- II. Larval and pupal period of *S. calcitrans* breed on alfalfa meal and wheat bran half and half by weight at 25° C., was 377 hours; at 30° C., 311.7.
- III. Larval and pupal periods of *S. calcitrans* breed on ground oats at 30° C. was 320.2 hours in one series of tests and 326.1 hours in another series of tests.
- IV. Pupal period of *S. calcitrans* at 100% R. H. was 177.2 hours.
- V. Only 10% adults were obtained from pupa placed over a saturated solution of NaCl, approximately 73% relative humidity at 25° C.

BOOK NOTICE

GUIDE TO THE STUDY OF THE WINGS OF INSECTS. By JAMES CHESTER BRADLEY. Pages 1-41, plates 1-67, (unbound). Published by Daw, Illston and Company, Ithaca, New York.

This is a paper-bound classroom manual accompanied by sixty-seven loose plates on each of which is printed, in scarcely visible ink, the wing of an insect, which is to be traced and lettered in india ink by the student. The nomenclature is that of the Comstock-Needham system with the modifications of the M-Cu region necessitated by the recent researches of Lameere, Tillyard and Martynov.

The editor feels that there should be a set of plates (a key or "pony") with the veins properly marked which could be used for reference by the teacher. At the end of the booklet are comparative tables showing the relation of this system to previously used systems. This is an excellent method of teaching venation.—C. H. K.

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NOTES ON SOME AMERICAN SPHECINÆ (HYM.).

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In 1913 it became possible for the writer to study the types of American Sphecinae now in Europe as far as it was possible to locate them. They are widely scattered in the different European collections and my studies took me from Naples to Lund and from Vienna to Oxford. In all, eleven places were visited but I was unable to visit Genoa, Geneva and Copenhagen where a few presumably are. Nor could I locate the Spinola collection. Most of Lepeletier's Sphecid types seem to have been described from this collection and I supposed the types would be in Paris. This proved not to be the case and Lepeletier's descriptions, while not particularly brief, are models, in this group at least, for giving only non-distinctive characters. In most cases, therefore, his species remain unrecognized.

Genus **Chlorion** Lat. (**Sphex** of many authors.)

The reasons for changing the generic name *Sphex* to *Chlorion* have been given by the writer in Entomological News, xv, 117, 1904 and xvi, 163, 1905, and perhaps more clearly in Proc. U. S. Nat. Mus., xxxi, 292, 1906. It is unnecessary, therefore, to consider them here. The position taken in those articles is fully sustained by Opinion No. 32 of the International Commission on Zoological Nomenclature.

Chlorion (Chlorion) cyaneum Dahlb. This species has been and still is often referred to as *Chlorion* or *Sphex coerulea* L. This is incorrect. Linné in the tenth edition of the Systema Naturæ, p. 571, described *Sphex coerulea* from "America

meridionali." Kohl has expressed the opinion that this description refers to some southern species of *Pepsis*. In any case it does not agree with the species here concerned. In the twelfth edition of the *Systema Naturæ* Linné repeats this description on page 947 as species No. 38, while on page 941, as species No. 2, he describes another *Sphex coerulea* from "America septentrionali" which agrees with our North American species fairly well. The name cannot hold, however, for the other one (on page 947) is the same, word for word, as the one in the tenth edition which therefore has priority. Catesby, De Geer and Drury seem also to have written about the *coerulea* No. 2 of the twelfth edition but use either *coerulea* or no name at all. Fabricius recognizes both of the Linnean species, which in his *Systema Piezatorum* he places in the genus *Pepsis*, by references to the twelfth edition of the *Systema Naturæ*, but seemingly has noted the duplication of the name for he renames the preoccupied one, *cyanea*. This would seem to provide the species with a name, but in the Fabrician collection at Kiel, arranged both by name and number to correspond with the *Systema Piezatorum*, and presumably so arranged by Fabricius himself, are three specimens, placed under that name and number, which upon examination proved to be the common *Chalybion cyaneum* Dahlb, one of the mud daubers, and entirely different from the insect under consideration.

If Fabricius was acquainted with Linné's specimens and correctly identified his own, it would follow that neither Linné's nor Fabricius' names could apply here. In any case the Fabrician one cannot.

The first name to become available for the species is that given by Dahlbom (*Hym. Eur.*, I, 24, 1843) who gave it the name *Chlorion cyaneum*. As he recognizes the Fabrician species also, as *Chalybion cyaneum*, with references to Linné, DeGeer and Fabricius, no confusion of the two is possible. Accordingly, *cyaneum* is the first available name for this insect and as it is still placed in the genus *Chlorion* its name is *Chlorion (Chlorion) cyaneum* Dahlb.

Chlorion (Priononyx) striatum (Sm.). The type of *Sphex (Priononyx) laerma* Cam. in the British Museum upon examination proves to be this species and the "?" before the reference to it on page 335 in my paper (*Proc. U. S. Nat. Mus.*, xxxi, 1906) can be deleted. In Vienna, Kohl has labelled specimens of

striatum as *johannis* Fab., showing his opinion as to the identity of the two, but I was unable to find a positively Fabrician specimen of *Pepsis johannis*, as Fabricius called it, in any of the European collections, so the relation of the two cannot be considered as proven.

Chlorion (Priononyx) atratum (Lep.). I have now seen specimens of this species from Oregon and Washington, thus giving it a continuous distribution across the northern border states.

Chlorion (Priononyx) thomæ (Fab.). In the Fabrician collection at Kiel are four specimens, all males, under the label *thomæ*; also a large female of the same species under the label *crucis*. Evidently Fabricius did not recognize their identity. *Thomæ*, having been described first, is the name which holds. In Paris is a specimen bearing the Fabrician label "P. crucis p in Guadeloupe fab" but it is *Chlorion (Ammobia) ichneumoneum aurifluum* Perty.

Chlorion (Priononyx) pubidorsum (Costa). In the Achille Costa collection at the University of Naples is undoubtedly the type of this species, published in 1862, labelled "M Zool No 7882"; "Enodia ♂ 11.76 pubidorsum A Cos Biogian." This is the species hitherto generally called *Chlorion (Priononyx) bifoveolatum* (Tasch.), published in 1869. The identity of these species (I have also seen Taschenberg's type) is certain, but I have not been able to learn the meaning of the word "Biogian" on the label. I have named and sent out many specimens of this species during the last twenty-five years labelled *bifoveolatum* Tasch. which should be corrected to *pubidorsum* A. Costa.

An examination of the type of *Chlorion (Priononyx) excisum* (Kohl) at Vienna confirms the belief I expressed in Proc. U. S. Nat. Mus., xxxi, 417 that this insect is only a variant of *pubidorsum*.

Chlorion (Priononyx) neoxenum (Kohl). I think that Kohl was correct in his opinion that the specimen from which he described this species bore a wrong locality label and that instead of coming from Vancouver Island was South American. It is the same as my *simillimum* from Argentina. From a study of the type of *Chlorion (Priononyx) ommissus* (Kohl) I am of the opinion that this will prove to be the male of *neoxenum*.

Chlorion (Isodontia) aztecum (Sauss.). The type of Cameron's *Isodontia robusta* ♀, in the British Museum is this species, but with an unusually dark costal margin of the wings.

Sphex apicalis Smith, (Hym. Brit. Mus., iv, 262, 1856) has generally been supposed to apply to the species now known as *Chlorion (Isodontia) harrisi* Fern., the name *apicalis* being pre-occupied. Examination of Smith's type, however, shows that it is not this species, but the one known as *Chlorion (Isodontia) aztecum cinereum* Fern. Had the name *apicalis* not been made use of previously, this discovery would have necessitated a number of changes which fortunately are not needed.

Subgenus **Ammobia** Bilb.

When I proposed the subgenus *Proterosphex* (Proc. U. S. Nat. Mus., xxxi, 65, 1906) I failed to give sufficient consideration to Billberg's paper. Mr. Rohwer has correctly substituted *Ammobia* Billberg for my *Proterosphex*.

Chlorion (Ammobia) habenum Say. The type of *Sphex princeps* Kohl, "Vaterland unbekannt, wahrscheinlich Australien" in the Vienna Museum is unquestionably this species: *princeps* accordingly, is a synonym of *habenum*. I have now seen specimens from Honduras, Guatemala and Mexico in addition to the localities previously listed.

Cameron describes his *Sphex guatemalensis* from both sexes. In the British Museum I could find only two specimens so marked, both females. One of these is *Chlorion habenum* Say while the other is a true example of *guatemalensis* (see below).

Chlorion (Ammobia) opacum (Dahlb.). One male labelled "Sphex opaca Am. merd." in Dahlbom's writing is in the Dahlbom collection at the University of Lund and is what has been generally called *Chlorion (Ammobia) flavitarsis iheringii* (Kohl). In consequence, the names of the species and subspecies concerned must be rearranged, *Chlorion flavitarsis iheringii* (Kohl) becoming *Chlorion opacum* (Dahlb.); *Chlorion flavitarsis* Fern. becoming *Chlorion opacum flavitarsis* Fern.; *Chlorion flavitarsis saussurei* Fern. becoming *Chlorion opacum saussurei* Fern. and *Chlorion flavitarsis guatemalensis* (Cam.) becoming *Chlorion opacum guatemalensis* (Cam.).

In the British Museum is a male *Chlorion* labelled "flavovestita Type Sm." but with no locality or catalogue number. Smith described this species as from India but it is certainly *opacum*. It seems probable that the locality given by Smith is erroneous.

Chlorion (Ammobia) nudum Fern. I now have records of captures of this species from King William Co., Va., July; and from Jocassee, S. C., August 19; and of its probable female, *Chlorion (Ammobia) bridwelli* Fern. from "near Alto Pass. Union Co., Ill." and Wesson, Miss., both taken in August, thus considerably extending the known range of these species.

Chlorion (Ammobia) caliginosum (Erichs.). Five specimens, all females, labelled *erythroptera* Cam. in the Biologia collection at the British Museum, none marked Type, agree with specimens of *caliginosum* Erichs. in the Berlin Museum labelled Type. One of these last is also marked "caliginosa N Brasil" enclosed by a black line and on green paper. I was informed that this is a Klug label. If so, it would seem that Erichson adopted Klug's museum label for his own to publish.

Chlorion (Ammobia) singularis (Smith). The type of this species; of Cameron's *singularis*; of Costa's *chlorargyrica* and of Kohl's *spiniger* have all been studied and are the same species. Smith's name, being the oldest, must hold for this insect. A male specimen in the Banksian collection at the British Museum, labelled *ichneumonea* is also this species. At Oxford, a female *Chlorion* bearing the four labels: "Ega Bras"; "singularis Ega Smith"; "I see no difference between this and specimens of *S. barbara* from Texas in Mus. Smith"; "Coll Smith 1879" does not agree with the London specimen at all well and is likely to prove to be *Chlorion (Ammobia) brazilianum* (Saussure). *Tinctipennis* Cam. is no more than a variety of this last.

Pepsis fervens Fab. (not Linné). The species so named by Fabricius in his *Systema Entomologiæ*, is recorded as from "India orientali." There are two specimens placed under this name in the Fabrician collection at Kiel, but being supposedly Asiatic, I did not examine them. In the Paris Museum, however, I found a specimen bearing the Fabrician label "p. fervens p St Domingue fab" and a second, "Museum Paris St Domingue Coll Bosc 1828. Whether this specimen is the same species as those at Kiel I am unable to say, but in any case the one in Paris is what has been known as *Chlorion (Ammobia) resinipes* Fern. As it is not the Linnean *fervens*, however, *resinipes* still holds as the name of the San Domingo species.

Chlorion (Ammobia) fuliginosum (Dahlb.). In the Berlin Museum are three specimens of this species, two males and a female. One male bears the labels: "Type"; "fuliginosus M Dahlb." and "fuliginosa N Brasil" (and an undecipherable word). This last label is Klug's usual one. The other male has the genitalia mounted on a card, below which are: a blank white label; "fuliginosa" in Dahlbom's writing; and "Type." These two would seem to be Dahlbom's types. The female is marked "Type"; and "Sphex congener Kohl." I suspect that as Kohl described *congener* from females, this is one of his types, sent here to go with the males as *congener* is undoubtedly the female of *fuliginosum*. At Lund is a specimen marked "73"; "Tranquebar"; and "Sphex fuliginosa Berl. Mus. Ent. Er. e Brasil." This insect does not seem to be of the same species as the others.

Chlorion (Ammobia) latro (Erichs.). At Berlin are two specimens, male and female. The latter has only one label, reading "Type": the male has four: "Type"; "latro Er. Br. Guy." followed by a word something like "Whonat"; "4701" and "Sphex roratus Kohl ♀." The identity of the two species had evidently been determined when this last label was prepared, though in Kohl's paper (Ann. k. k. naturh. Hofmus., v, 219, 1890) he only suggests the possibility that they may be the same. I have seen the types of both species and place *roratus* in the synonymy.

Chlorion (Ammobia) melanopum (Dahl.). A specimen of this species at the Berlin Museum carries three labels: "melanopa Dahl."; "Type"; and "Sphex *ruficauda* Taschenberg." It is probably Dahlbom's type as I found no specimens of this species at Lund. The type of *Sphex proxima* Smith in the British Museum and that of *Sphex ruficauda* Tasch. at Halle are both this species, thus proving Kohl's belief as to their identity to be correct.

Chlorion (Ammobia) dubitatum (Cress.). The types of *Sphex micans* Tasch., described from five females are of the same species as Cresson's *dubitata*. I have seen the types of both. It is quite likely that Smith's *dorsalis* is also the same though I found no specimens in the British Museum bearing his label. Four at Oxford, named in his writing, are this species, though. Smith considered his specimens to be Lepe-

letier's *dorsalis* which may be correct, but this type, being in the Spinola collection, which I was unable to locate, makes it impossible to prove their identity at present. Until this point has been settled, therefore, this insect must be known by Cresson's name.

Genus **Sphex** L. (**Ammophila** of many authors).

Reasons for the use of the name *Sphex* instead of *Ammophila* have already been presented elsewhere. I may be permitted to repeat, however, the statement that the original species of the genus, published by Linné in the tenth edition of the *Systema Naturæ*, by rule must furnish the genotype. By 1805, though, all of these had been removed to other genera while other species, many of them really belonging elsewhere, had been added to *Sphex* by a number of describers. It may be well, therefore, to call attention here to the point that Fabricius seems to have realized this situation, for in 1804, in his *Systema Piezatorum*, he groups the different species in the genera *Pelopaeus*, *Sphex*, *Pepsis* and *Chlorion*. In *Sphex* he places four species: *sabulosa* L., the first one named by Linné; and three of his own. All of these belong in *Sphex* (s. str.) as used here. Under *sabulosa* he correctly gives as a synonym *Ammophila vulgaris* Kirby, and under *Pepsis arenaria* he gives as a synonym *Ammophila hirsuta* Kirby, now a *Podalonia*. This synonymy evidences that, at least as far as the species he (Fabricius) included in this book are concerned, he did not recognize *Ammophila* as a valid genus, and his restriction of *Sphex* to species which are still congeneric and one of which was Linné's *Sphex* No. 1, would indicate that he was trying to purify an assemblage of species belonging in numerous genera and select as members of *Sphex* those species congeneric with Linné's "chef de file."

In the following synonymy the names of species of which I have studied the types are preceded by a *.

Sphex abbreviatus (Fab.). In the collection at Kiel under "34 *Pelopaeus*"; "8 *abbreviatus*" are two male specimens. either would fit the description fairly well but they are different species. The first is the same as a specimen in the Berlin Museum marked "Brasilien"; "4851"; "melanaria N," and one at Lund marked "Brasilia Berl. mus"; "melanaria Kl";

"Am. binodis Fabr. certe, see Mus. Havn. p. 8, Am. melanaria K M. 13. Dlbn H. E. 15." Both of these last are males and one or both were undoubtedly the insect or insects used by Dahlbom in preparing his description of *Ammophila melanaria*. In view of the fact that Dahlbom gives "Kl. Mus. Berol" in connection with his description it would seem that type value should be given to the Berlin specimen rather than to the one at Lund.

With the original description of *abbreviatus* fairly applicable to either species at Kiel, and with the first one certainly the same as *melanaria*, I have decided to consider the Fabrician specimen standing second after the label as Fabricius' type, thus avoiding the synonymy which would otherwise be involved.

Many writers have identified and listed *abbreviatus* from North America. Thus far I have failed to find in any of these a true example of this species and doubt if it occurs any great distance, if at all, northward into Central America. The insect usually marked by this name, captured in the United States, is **Spheg aureonotatus* (Cam.). Sometimes it has been identified as *Spheg* or *Ammophila gracilis* Lep., but *gracilis* appears to have some ferruginous on its abdomen (Rohwer—in lit.—agrees with this) to judge from the description.

****Spheg binodis* Fab.** This species has not been recognized from the description. In the Paris Museum I found an insect bearing the three labels: "S. binodis p Cajanne fab" in Fabricius' writing; "Museum Paris Cayenne Coll Bose 1828"; "abbreviata det Kohl ♂." As Fabricius described the species from "Cajenne Mus. Dom. Bosc" there would seem to be little doubt that this specimen is the type. The last label probably means that Kohl saw this insect and considered it the same as *Spheg abbreviatus*, and that as it is a female, he regarded it as of the other sex of *abbreviatus*. This is probably correct.

****Spheg arvensis* (Dahlb.)** The type is in the Dahlbom collection at Lund, marked: "Ammoph. arvensis Berl. mus. eul (col?) Er. ♂ ♀ Pensylv. Zimrmn." It is a male. Dahlbom writes after his description of this species: "Ammophila id. Klug. Mus. Berolin. Exemplar unicum e Pennsylvania Americae borealis amice communicavit Cel. Dr. Zimmermann."

The one in the Berlin Museum referred to is probably the one marked: "N. Amerika"; "inepta Cr. det. Kohl"; "arvensis

N Am. sept.”; this last in Klug’s handwriting. As the specimen at Lund has a petiolated third cubital cell in each fore wing it is evidently Dahlbom’s type which he placed under *Miscus* because of this venation. I have examined nearly two thousand insects of this species from all parts of North America but have found no other case of a petiolated third cubital cell, so consider the type as having an abnormal venation. The Berlin specimen has the normal venation. This view is also supported by the fact that in the right fore wing of the type only the front third (about) of the first transverse cubital vein is present. I find, though rarely, an example of some species of *Sphex* in which the third cubital cell is almost petiolated, but one or two, only, among hundreds of the specimens examined. I am not prepared to attack the validity of *Miscus* as an Old World genus, but am positive that it is not present in North America and that any specimen of *Sphex* having a petiolated third cubital cell is only an individual deviation from the normal.

As synonyms of *Sphex arvensis* I place **Ammophila urnaria* Dahlb., of which at Lund are two specimens, one from “S. Carolina Zimrmn”; the other marked “urnaria Kl. Mus. Berl.” As Dahlbom gives South Carolina and Pennsylvania for habitat and states that he received specimens from Zimmermann the former is undoubtedly one of those from which his description was made. I could not find any specimens at Berlin which I could feel certain had been seen by Dahlbom. As synonyms I also place **Ammophila vulgaris* Cress.; **Ammophila mediata* Cress, and **Ammophila inepta* Cress.

This species is the most widely distributed of any American *Sphex*. I have seen an example from Fort McLeod, about 55° north latitude; from Guatemala, and from practically every State and from Mexico. As might be expected, it varies greatly and Cresson’s descriptions are of variations, with specimens he identified as *urnaria* the typical *arvensis*.

The chief varying characters in this species are the degree of pilosity and its color; the area covered by ferruginous; and size. *Vulgaris* is a very pilose, white haired form; *mediata* averages slightly larger and the hairs on the head (and sometimes on the prothorax) are brown, while *inepta*, found more frequently in the southern states, is liable to be more slender in proportion to its length and rather sparsely pilose. The

amount of surface which is ferruginous seems to be determined by the humidity of the locality where the insect occurs, a relation already discussed in connection with *Sphex procerus* (Ann. Ent. Soc. Am., xix, 88, 1926) Size seems to be extremely variable in the same species and it has been suggested that this may be due to different amounts of food supply stored for the young to feed upon, either from difficulty in finding enough, or possibly from haste because of a necessity for immediate egg deposition. Examples which might almost be termed dwarfs are certainly often met with in *Sphex* and *Podalonia*, while others, almost gigantic in comparison, also occur.

Aside from the differences just named, and between the limits of which all intermediate conditions occur, I have been unable to find any stable morphological characters by which the above named species can be separated.

****Sphex procerus*** (Dahlb.). This species, like the last, has a very wide distribution and is very variable. Its synonyms are: **Ammophila gryphus* Sm., ♀ ♂; **A. saeva* Sm., ♀; **A. conditor* Sm. ♀; **A. macra* Cress., ♂; *A. barbata* Sm., (no type found, either in the British Museum or at Oxford); **A. ceres* Cam. ♂; **A. championi* Cam., ♀; and **A. striolata* Cam., ♀.

The range in size of this species is enormous and the amount of ferruginous on the abdomen also varies greatly. In *saevus* Sm. from California and *striolatus* from Ventanas, Mex. the black is greatly reduced, giving the abdomen an almost entirely ferruginous appearance above. When one female is eighteen millimeters long and another is twice that length, and when in some cases the abdomen shows only slight traces of ferruginous while in others it is nearly all of that color it seems almost impossible that only one species is involved. Yet structurally no fixed differences seem to occur, and reluctantly I have come to believe that all the different names listed above belong to the same species.

****Sphex breviceps*** (Sm.), ♀. I am unable to separate **Ammophila pruinosa* Cress. and **A. varipes* Cress. from Smith's *breviceps*. **A. comanche* Cam. is also a synonym. The species is a variable one, in some regions being only slightly pubescent, but densely clothed with erect hairs, while in others the pubescence is very complete and the erect hairs rather few. All intergrades between these extremes occur and the

amount and distribution of the ferruginous is also very variable. No fixed morphological differences have thus far been found, however, though a typical *pruinosa* looks quite different from a typical *breviceps*.

****Sphex placidus* (Sm.).** This species, described from California, proves to be the same as the later published *Ammophila pictipennis* Walsh, **A. extremitata* Cress., **A. anomala* Tasch. and *Sphex nigropilosus* Rohwer. I have not myself seen Rohwer's type, but have examined specimens from the same locality, loaned me by the U. S. National Museum and do not find two teeth on any of the claws. Others, who have examined the type, also fail to find a second claw and are of the opinion that *longispinus* might well be placed as identical with *pictipennis*.

Western and southern specimens of this species are larger, stouter and more coarsely marked than northern and eastern ones, which probably explains why *placidus* has not heretofore been recognized.

***Sphex aberti* (Hald.).** The type has been lost, but the insect is so distinctive in its typical condition there can be little doubt as to its identity. **Ammophila yarrowi* Cress. and **A. montezuma* Cam. are synonyms.

This is such a variable species in different parts of its range that only a long series of intergrading examples has kept me from describing several new species from the lot!

****Sphex politus* (Cress.), ♀.** The male of this tiny species has since been described by Kohl as **Ammophila nearctica*.

****Sphex ferruginosus* (Cress.).** This striking species is in all probability the female of Cresson's *collaris* ♂, though proof of this is lacking. Nor can I separate it from *Coloptera wrightii* Cress. structurally, except by the size. The original basis for the establishment of *Coloptera* was the presence of two (first and second) cubital cells only, caused by the obliteration of the second cubital cross vein, or by the fusion of the second and third cross veins. This distinction now seems to be of little value owing to abnormalities of venation which are quite common in this group, but others, such as the form of the collar and its transverse rugosity, etc., have led Kohl to include several species in an "Artengruppe" with the name *Coloptera*. As *wrightii* and *ferruginosus* have these characters in common

and differ only in size (and with intermediates, here) I find no reason for separating them. The type itself of *wrightii* has two cubital cells in the left fore wing and three in the other, the third, however, lacking the central third of the third transverse cubital vein! This subject will be discussed further, elsewhere.

Sphex harti new name. The species described by Hart as *Ammophila argentata* had not previously been named but its transfer to the genus *Sphex* as *Sphex argentatus* is not possible as Fabricius described a *Sphex argentatus* in 1787. I therefore replace this preoccupied name by the specific name *harti* in recognition of the original describer of the species.

Genus *Chalybion* Dahlb.

Chalybion cyaneum (Fab.). The discussion above, on *Chlorion coeruleum* should have made it plain that the name *coeruleum* cannot be used, either for the digger wasp, *Chlorion*, or the common mud dauber, *Chalybion*, as has even recently been done. The first name hitherto recognized as available for the mud dauber was given by Dahlbom, but under his description he gives references to Linnè, *Systema Naturæ*, Ed. 12 and Amoen, *Acad.*, 6; DeGeer, *Mem.* 3; Fabr., *Ent. Syst.*, 2, 201, and *Syst. Piez.*, 211. These follow his words: "*Sphex cyanea*," but the first three when checked (by Dalla Torre's *Catalogus*) prove to be under the name *coerulea*! The Fabrician references are to the name *cyanea* and as the types at Kiel under the name and number referred to by Dahlbom are the same species as those so named in the Dahlbom collection we can safely attribute the name *cyanea* to Fabricius rather than to Dahlbom.

ON "DYAR'S RULE" AND ITS APPLICATION TO SAWFLY LARVAE.*

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INTRODUCTION.

✓ Forty years ago Dyar (1890) sought to establish a criterion by which it would be possible to determine, by simple mathematics, the correctness or incorrectness of the number of instars observed. This was based upon the apparent close agreement between calculated and actual widths of the heads of all larval instars of 28 species of caterpillars, which had from four to ten stadia. In most cases, the calculated and observed widths were either identical or within 0.1 mm., though, apparently, a discrepancy of 0.2 mm. was not considered significant. In six cases of greater deviation in various instars among these species, the explanation offered was "abnormal development"—either dwarfing, because the larva was "unhealthy" and failed to cast its skin, etc., or unusual growth. In five other cases, probable incorrect measurements were admitted. From these data, Dyar found that the size of the larval head is (relatively) static during a stadium and that "... the widths of the head of a larva in its successive stages follow a regular geometrical progression..." (It was suggested that the width of the larval head is the most convenient measurement to take.)

It was not stated that this principle might apply generally; indeed, since the title restricts the article to "lepidopterous larvæ" and the species dealt with are all caterpillars, it might be construed that this rule may apply only to Lepidoptera. The impression that this is true is shared by some entomologists. Dyar's Rule has become better known than similar ratios¹ and

*The material for this paper was gathered while the writer was in the employ of the Maine Forest Service and acknowledgment is herewith made. The writer is indebted to Dr. F. L. Campbell for valuable suggestions in the preparation of the paper.

¹Dyar was not the first to attempt the formulation of growth rules. In a recent paper, Calvert (1929) includes a comprehensive historical treatment of the work done on growth rates in Arthropoda and on the attempts to establish mathematical constants for the change in dimensions between instars.

has been incorporated in several entomological texts, e.g., Comstock, Imms, where it is not definitely stated how extensively or how reliably it may hold. While this rule has been utilized in determining, or in corroborating, the number of larval instars in a number of instances, these have been chiefly species of Lepidoptera. Applications of Dyar's Rule in groups other than this order apparently have been rare. Two instances have been noted: Wu (1923) found a ratio of increase of approximately .95 for 22 "larval" instars of the stone-fly, *Nemoura* (from Calvert), and Calvert (1929, p. 253, footnote 10) utilized Horsfall's (1929) data on head capsule widths in successive instars of the grapevine sawfly, *Erythraspides pygmaeus* (Say).²

APPLICATIONS OF DYAR'S RULE TO SAWFLY LARVÆ.

The purpose of this paper is to present the data and conclusions of two tests of the application of Dyar's Rule to sawfly larvæ. One test is concerned with one hundred head measurements of each of the seven instars of the birch leaf-mining sawfly, *Phyllotoma nemorata* (Fallen), and the analysis of these with respect to range, modes, means, calculated means, Probable Error, and the like, per instar. The other test is concerned with series of head measurements (based upon an unknown number of individuals per instar but probably very few or single in each case) of 46 species of sawfly larvæ described by Dyar and quite comparable to the sort of data upon which Dyar's criterion was based.

In the summer of 1929, in the course of a biological study of the birch leaf-mining sawfly, a series of head capsules were measured at daily intervals from the time of hatching until the cocoon, or hibernaculum, had been formed by the prepupa. It was noted that the feeding stages of this sawfly fell into definite groups according to their head widths, and that these groups exhibited a common ratio of increase, i.e., the head widths formed a geometrically progressive series—except the non-feeding, last larval instar or prepupa, the head capsule of

²Calvert calculated the successive growth-factors as follows: 1.67, 1.50, 1.31, 1.21, 1.16, in this case (using the reciprocals of Dyar's ratios which, in the same order, would be .60, .67, .77, .82, .86). The degree of variation here is very considerable and it is evident that Dyar's Rule does not hold when applied to Horsfall's measurements of this sawfly.

which does not increase in size. These groups, moreover, corresponded with the apparent total number of cast skins per individual larva obtained from the mines. So consistent were these measurements, that Dyar's principle was accepted as one of the bases for deciding upon the number of instars in a paper recently published (Taylor 1930).

Later, to test the application of Dyar's Rule to this sawfly still more extensively, one hundred individuals of each of the seven³ instars were measured, with the result that the conclusion derived from the preliminary measurements is sound, apparently, provided only the modes and means are considered. These data are presented in Table I and are analyzed in Table II. All measurements were made of the dorsal aspect of the head capsule at its greatest width⁴ with a micrometer disc—ruled into five divisions of ten fine units each—in one (9x) ocular. The objective was 2.3x, hence, in reducing the micrometer fine unit readings to mm., the divisor was 23 and each fine unit equalled 0.04348 mm. Readings in each case were made to

³If the non-feeding, "ultimate stage" of Dyar (1896), or prepupa, be included, a number of sawflies have seven instars in females and one less feeding instar in males (Middleton, 1923; Severin, 1920; Horsfall, 1929). Dyar's data indicate that this is apparently likewise the case with *Phylotoma mcleayi* Leach and others, though this was not apparent to him since he interpreted his data as referring to the same number of instars for each sex, with apparent marked sexual differences in the size of the head capsules. Of this species, he says (1895b, p. 210):

"In the last moult there is no increase in the size of the head, but the larvæ feed in the last stage. [This feeding is not true of sawfly larvæ in general.] The male larvæ are smaller than the female, and their heads do not enlarge at the moult before the last, so they possess the anomalous character of having three stages without any growth of the head. I have never observed anything of this kind in the Lepidoptera, perhaps owing to their very different manner of moulting. In the saw-flies the old head is split at each moult, as in the Lepidoptera at pupation only, and the new one has to grow after the moulting instead of largely before it, as in the Lepidoptera."

Here is a possible explanation of why Dyar did not attempt—or, more strictly, to publish any such attempt—to apply his own rule to the large series of sawfly larvæ he described. The following quotation from the description of the first stage of *Strongylogaster pinguis* (1896a, p. 311): "...width .35 mm. (probably an error; .5 is the calculated width)" indicates that Dyar, at least in this case, did attempt to apply his own rule to sawfly larvæ.

All *Phyllotoma nemoralis* larvæ are female-producing so far as is known—no one has obtained a male and a count of 3,000 adults made over the entire emergence period for this specific purpose revealed no males—and all larvæ followed through had seven larval stages including the prepupa.

⁴Considerable variation in the *shape* of the head, which ranged from nearly circular to broadly crescentic or rectanguloid, appeared to be the primary factor in the degree of size variability found. (A perusal of Yuasa's (1922) paper inspires the impression that the shape of the entire head of Tenthredinoid larvæ may be considered a stable character, but, either this impression is incorrect or this instance is atypical).

estimated tenths of the fine units so that each successive point of the scale in Table I represents a head width greater by 0.004348 mm. The larvæ measured were mixed originally and final classifications to instar were not made until, *after* measurement, it was indicated that these classifications could be made safely, at least in the later stages. In the extreme cases, where the measurement was such that there was a question as to which stadium the larva belonged, it was possible to decide with the aid of other characters, *e.g.*, the general body size, the color of the head, which is pale immediately following ecdysis, any abnormality apparent in the shape of the head (See footnote 4), etc.

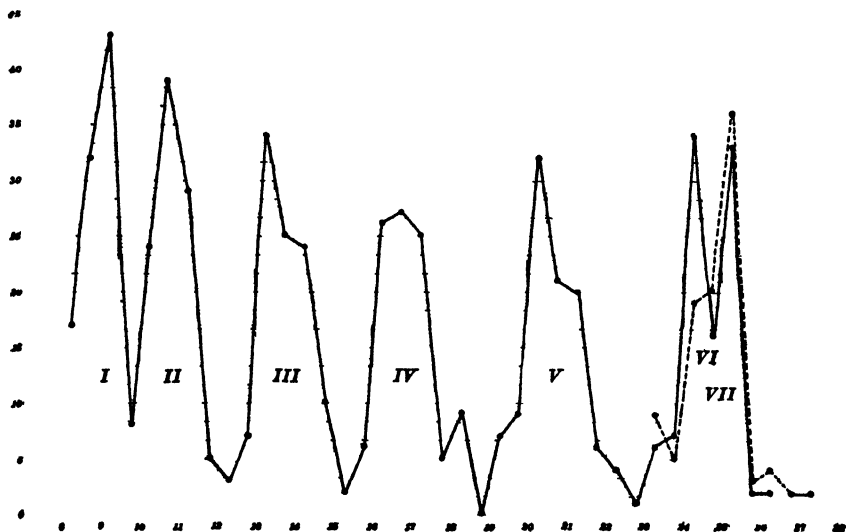


FIG. 1. A graph to show the distribution of *Phyllotoma nemoralis* larvæ, 100 for each instar, according to their head widths. It may be noted that the modal head width characterizes the instar in each case, that the extremes of the range for each instar tend to merge, and that the head capsule of the seventh instar—shown by dotted line—does not increase in width.

(The figures of the horizontal axis are in micrometer fine units and each point, as plotted, represents the frequency for each successive five-tenths of the micrometer fine units, *i. e.*, the frequencies of Table I thus are grouped by fives. Each successive head width is greater by approximately 0.02 mm.).

TABLE I.

The Distribution of *Phyllotoma nemorata* Larvæ According to Their Head Widths.

NOTE: Figures represent the number of individuals per head width. Units of the scale are *not* in mm., but in tenths of micrometer fine units as explained above. Each mean is marked.

Instar I	Instar II	Instar III	Instar IV	Instar V	Instar VI	Prepupa*
8.0- 4	10.0- 5	12.5- 2	15.2- 1	19.0- 4	23.0- 3	3
8.1- 6	10.1- 7	12.6- 2	15.3- 1	19.1- 0	23.1- 1	1
8.2- 3	10.2- 3	12.7- 2	15.4- 0	19.2- 1	23.2- 1	3
8.3- 1	10.3- 4	12.8- 1	15.5- 0	19.3- 0	23.3- 0	1
8.4- 3	10.4- 5	12.9- 0	15.6- 0	19.4- 2	23.4- 1	1
8.5- 4	10.5- 5	13.0-12	15.7- 3	19.5- 3	23.5- 2	2
8.6- 5	10.6- 6	13.1- 9	15.8- 1	19.6- 2	23.6- 0	1
8.7- 4	10.7- 8	13.2- 2	15.9- 2	19.7- 0	23.7- 0	0
8.8-10.	10.8-13	13.3- 5	16.0- 7	19.8- 2	23.8- 1	2
8.9- 9	10.9- 7	13.4- 6	16.1- 7	19.9- 2	23.9- 4	0
9.0-30	11.0-16	13.5- 2	16.2- 3	20.0-13	24.0-28	15
9.1- 5	11.1- 5	13.6- 1	16.3- 5	20.1- 8	24.1- 2	0
9.2- 3	11.2- 3	13.7- 3	16.4- 4	20.2- 7	24.2- 1	4
9.3- 4	11.3- 0	13.8- 8	16.5- 5	20.3- 2	24.3- 1	0
9.4- 1	11.4- 5	13.9-11	16.6- 5	20.4- 2	24.4- 2	0
9.5- 2	11.5- 3	14.0-12	16.7- 3	20.5- 8	24.5- 4	11
9.6- 2	11.6- 2	14.1- 3	16.8-10	20.6- 0	24.6- 0	3
9.7- 1	11.7- 0	14.2- 4	16.9- 4	20.7- 2	24.7- 3	2
9.8- 2	11.8- 0	14.3- 3	17.0-15	20.8- 7	24.8- 5	3
9.9- 1	11.9- 0	14.4- 2	17.1- 5	20.9- 4	24.9- 4	1
	12.0- 2	14.5- 3	17.2- 1	21.0-14	25.0-28	26
	12.1- 0	14.6- 0	17.3- 1	21.1- 3	25.1- 2	2
	12.2- 1	14.7- 5	17.4- 3	21.2- 0	25.2- 2	5
	12.3- 0	14.8- 1	17.5- 0	21.3- 3	25.3- 1	3
	12.4- 0	14.9- 1	17.6- 0	21.4- 0	25.4- 0	0
		15.0- 0	17.7- 2	21.5- 0	25.5- 0	2
		15.1- 0	17.8- 1	21.6- 3	25.6- 1	0
			17.9- 2	21.7- 0	25.7- 0	1
			18.0- 6	21.8- 1	25.8- 1	0
			18.1- 2	21.9- 2	25.9- 0	0
			18.2- 1	22.0- 3	26.0- 2	4
			18.3- 0	22.1- 0	26.1- 0	0
			18.4- 0	22.2- 0	26.2- 0	0
			18.5- 0	22.3- 0	26.3- 0	0
			18.6- 0	22.4- 1	26.4- 0	0
			18.7- 0	22.5- 1	26.5- 0	1
			18.8- 0	22.6- 0	26.6- 0	1
			18.9- 0	22.7- 0	26.7- 0	0
				22.8- 0	26.8- 0	0
				22.9- 0	26.9- 0	0
					27.0- 0	2

*The head does not increase in size at the molt preceding the prepupal stage.

TABLE II.

An Analysis of the Head Measurements of the Larvæ of
Phyllotoma nemorata per Instar.

NOTE: All calculations were made in the micrometer units for convenience, but conversions into millimeters were made in these final figures; the data in this table are in millimeters only.

All larvæ, except 89 of the prepupæ (from Hartland, Me.), were taken from an identical area, *vis.*, a small tract near the Entomological Laboratory at Bar Harbor, Me.

	I	II	III	IV	V	VI	VII
Size range	0.348 to 0.430	0.435 to 0.530	0.544 to 0.648	0.661 to 0.791	0.826 to 0.978	1.000 to 1.130	1.000 to 1.174
Modes	0.391, 0.383	0.479, 0.470	0.609, 0.565	0.739, 0.730	0.913, 0.870	1.087, 1.043	1.087, 1.043
Mean	0.385	0.469	0.594	0.728	0.892	1.064	1.072
Calculated Mean ⁵	0.385	0.472*	0.578*	0.709*	0.868*	1.064	1.304
Difference	0.000	0.003	0.016	0.019	0.024	0.000	0.232
Probable Error of Mean ⁶	±0.0012	±0.0013	±0.0017	±0.0020	±0.0022	±0.0019	±0.0024
Standard Deviation ⁷	0.0183	0.0201	0.0253	0.0289	0.0326	0.0278	0.0358
Coefficient of Variation ⁸	4.74	4.28	4.26	3.97	3.65	2.61	3.34

⁵In the determination of the calculated mean, the ratio of increase used was an *average*, which was obtained from the means of each instar as follows:

$$\frac{mI}{mII} + \frac{mII}{mIII} + \frac{mIII}{mIV} + \frac{mIV}{mV} + \frac{mV}{mVI} = \frac{.821 + .789 + .815 + .816 + .838}{5} = .816$$

Where the calculated mean is followed by an asterisk, it represents the average of *two* calculations, *i. e.*, one made by multiplying the calculated mean of each instar by .816 successively, starting with the known mean of VI for V, etc. to I; the other by dividing the calculated mean of each instar by .816 successively, starting with the known mean of I for II, etc. to VII. Thus the only actual (averaged) widths employed were those of I and VI. (In this case, the calculated means obtained by these two processes were virtually identical.)

⁶The Gaussian formula was used: P. E. = $\pm 0.6745 \times \frac{\text{Stan. Dev.}}{\sqrt{n}}$

⁷The formula used was:

$$\text{Stan. Dev.} = \sqrt{\frac{e_1^2 + e_2^2 + e_3^2 + \dots + e_n^2}{n}}$$

where e_1, e_2, e_3 , etc. are the deviations of the successive counts from the mean and n denotes the number of counts made.

⁸The Coefficient of Variation = $\frac{\text{Stan. Dev.} \times 100}{\text{Mean}}$

The result is an abstract number expressing the variability in *per cent* of the Mean.

The conclusions derived from Tables I and II are as follows:

1. The first six instars of *Phyllotoma nemorata* may be grouped by the widths of their head capsules provided only the "normal" or "average" widths (means or modes) are considered: An instar can be characterized by the average width of the head capsule.

2. A few random measurements, however, not only would be unreliable but might mislead since, as may be noted, the range of the head size per instar is considerable: An instar cannot be characterized by the width of the head capsule of single, or of a few, individuals with reliability.

3. The seventh instar, or prepupa, has a head capsule virtually identical⁹ in size with that of the sixth: Dyar's Rule, when applied to sawfly larvæ, must be qualified in this respect.

4. The modes are reasonably pronounced. (A tendency toward bimodality may be noted in Table I but this is not believed to be significant. It is not improbable that the difficulty of estimating to tenths of the fine units of the micrometer scale resulted in a tendency to overload certain whole numbers such as 20.0, 21.0, 24.0, and 25.0. The double modes so formed are close to the mean in each case. In Fig. 1 this artificiality is discounted largely by plotting the frequencies by halves of the fine units.)

5. The means of the first six instars form a definite geometric progression and the agreement of these with the calculated means is so close that it is evident that Dyar's Rule, when qualified as described above, holds for this species. (Additionally, it may be noted that the Probable Error is low throughout.)

⁹Apparently it is generally true of sawfly larvæ that the head capsule of the prepupa does not increase in size, or at least not proportionately, over that of the preceding instar. In this species, the head of the prepupa retains the characteristic pale color in marked contrast with the light to dark brown of the heads of the feeding instars. The head of this stage, also, approximates the vertical in position in contrast with the nearly horizontal head of the earlier instars of this leaf-mining species.

(Marlatt (1890), who was one of the first to note the considerable differences between the larvæ of the penultimate and ultimate stages, believes the molt preceding the prepupal one to be "supplemental" and—since, in general, it just precedes the inert, over-wintering state—that it is "analogous to the one before pupation proper in insects, which in Tenthredinidæ is commonly undergone a few days only before the emergence of the mature insect.")

6. The Coefficient of Variation, as applied in this case, indicates that all the instars are rather similar in their degree of variability.

No other comparable series of measurements per instar of other sawfly larvæ was made, nor were similar data available in the literature. It was decided, however, to test the application of Dyar's Rule with certain head measurements of sawfly larvæ by Dyar (1893) (1894) (1895a) (1895b) (1896) (1897) (1898a) (1898b) (1900). With the possible exception of the instance noted in footnote 3, Dyar did not apply his own principle to these measurements, which were given in connection with the descriptions of the larvæ. These data (Table III) are treated by the writer in the same superficial manner as Dyar treated measurements of a series of caterpillars in seeking to establish his criterion. The data of other authors could be utilized similarly but have been omitted, primarily because the number of individuals measured per instar are usually either not given or are too few to yield entirely dependable results. (Dyar's data, though similar in this respect, are used because they are comparable to his data from which the rule was derived.)

Despite the superficial manner of using a ratio of increase based upon a single division and dealing with measurements based upon few or single individuals per instar—following Dyar in this respect—it, nevertheless, may be seen that, in general, as close an agreement between these actual and calculated measurements has been obtained for sawfly larvæ as Dyar found with a smaller series of lepidopterous larvæ.

TABLE III.

The Application of Dyar's Rule to Some Sawfly Larvæ Described by Him.

NOTES: The following genera have different larval habits which are indicated as follows: G=gall-formers, M=leaf-miners, F=free feeders.

The dates following the authors of the specific names indicate the appropriate references among Dyar's papers.

Where Dyar has given the last stage—the "ultimate" or prepupal one—it has been excluded from consideration, since the head width does not change. See the foregoing text and footnote 9.

All measurements are in millimeters.

For explanation of the reference marks see page 462.

Species ¹⁰	Type of Measurement	Successive Larval Stages ¹¹							Ratio of Increase ¹²
<i>Hemichroa americana</i> Prov. 1893	F act. calc.	.30 .26	.40 .36	.55 .51	.75 .71	1.00 1.00	1.40 1.00		.714
<i>Craesus latilarsus</i> Nort. 1893	F act. calc.	.40 .44	.55 .61	.75 .84	1.05 1.16	1.60 1.60	2.20 1.60		.727
<i>Fenusa varipes</i> St. F. 1893	M act. calc.	.25 .21	.30 .29	.40 .40	.55 .55	.75 .55			.733
<i>Monostegia quercus-coccinea</i> Dyar 1894	F act. calc.	.25 .31	.40 .42	.55 .58	.80 .80	1 10			.727
<i>M. quercus-alba</i> Nort. 1894	F act. calc.	.25 .26	.35 .36	.50 .50	.70				.714
<i>Nematus coryli</i> Cress. 1894	F act. calc.	.45 .42	.65 .60	.90 .87	1.25 1.25	1.80			.694
<i>N. salicis-odoratus</i> Dyar 1894	F act. calc.	.30 .36	.50 .51	.70 .71	1.00 1.00	1.40			.714
<i>N. similis</i> Nort. 1895a	F act. calc.	.40 .40	† .50	.60 .62	† .77	.90 .96	1.20 1.20	1.50	.800
<i>N. mendicus</i> Walsh 1895a	F act. calc.	.30 .34	† .43	.55 .55	† .70	.90 .90	1.15		.782
<i>N. pingui dorsum</i> Dyar 1895a	F act. calc.	1.00 .97	1.30 1.30	1.75					.743
<i>N. dorsivittatus</i> Cress. 1895a	F act. calc.	.65 .71	1.00 1.00	1.40					.714

TABLE III—Continued.

Species ¹⁰	Type of Measurement	Successive Larval Stages ¹¹								Ratio of Increase ¹²
<i>N. ventralis</i> Say 1895a	F	act. calc.	.55 .51	.75 .71	1.00 1.00	1.40				.714
<i>N. corylus</i> Cress. 1895a	F	act. calc.	.70 .71	1.00 1.00	1.40					.714
<i>N. thoracicus</i> Harrington 1895a	F	act. calc.	.25 .24	.33 .34	.50 .48	.70 .69	1.00 .98	1.40 1.40	2.00	.700
<i>Strongylogaster</i> <i>pinguis</i> Nort. 1895a	F	act. calc.	.35 .34	† .48	.60 .69	1.10 .98	1.40 1.40	2.00		.700
					(See also footnote 3)					
<i>Cladius</i> <i>gregarius</i> Dyar 1895b	F	act. calc.	.30 .30	.40 .45	.65 .67	1.00 1.00	1.50			.667
<i>C. solitarius</i> Dyar 1895b	F	act. calc.	.50 .51	† .64	.80 .80	1.00				.800
<i>Harpiphorus</i> <i>varianus</i> Nort. 1895b	F	act. calc.	.40 .50	.55 .60	.65 .72	.80 .87	1.10 1.04	† 1.50 1.25	1.80 1.50	.833
<i>Hylotoma</i> <i>mcleayi</i> Leach 1895b	F	act. calc.	1.10 1.11	1.40 1.40	1.75 1.75	2.20				.795
<i>H. pectoralis</i> Leach 1895b	F	act. calc.	.60 .65	.70 .80	.90 .98	† 1.40 1.20	1.80 1.47	2.20 1.80		.818
<i>Fenusia</i> <i>curtus</i> Nort. 1895b	M	act. calc.	.30 .32	.40 .42	.60 .56	.75 .75	1.00			.750
<i>Harpiphorus</i> <i>maculatus</i> Nort. 1896	F	act. calc.	.28† .29	.40 .38	† .49	.60 .64	.80 .83	1.08† 1.08	1.40†	.771
<i>Hylotoma</i> <i>scapularis</i> Klug 1897	F	act. calc.	.80 .94	1.10 1.30	1.80 1.80	2.50				.720
<i>Tenihredo</i> <i>remota</i> MacG. 1897	F	act. calc.	.60 .65	.80 .80			1.40 1.47	1.80 1.80	2.20	.818
<i>Harpiphorus</i> <i>tarsatus</i> Say 1897	F	act. calc.	.50 .53	.60 .66	.80 .82	1.00 1.02	1.20 1.28	1.60 1.60	2.00 2.00	.800

TABLE III—Continued.

Species ¹⁰	Type of Measurement	Successive Larval Stages ¹¹							Ratio of Increase ¹²
<i>H. versicolor</i> Nort. 1897	F	act.	.33	.50	.80	1.10	1.50	2.10	.714
		calc.	.39	.54	.76	1.07	1.50		
<i>Schizocerus prunivorus</i> Marlatt 1897	M	act.	.40	†	.60	.75	†	1.15 1.40	.821
		calc.	.43	.52	.63	.77	.94	1.15	
<i>Pontania populi</i> Marlatt 1897	G	act.	.36	.55	.70	1.00			.700
		calc.	.34	.49	.70				
<i>P. terminalis</i> Marlatt 1897	G	act.	.30	.40	.55	.80			.688
		calc.	.26	.38	.55				
<i>Pteronus populi</i> Marlatt 1897	F	act.	.60	.75	1.20	1.60	2.20		.727
		calc.	.61	.84	1.16	1.60			
<i>Pachynematus gregarious</i> Marlatt 1897	F	act.	.35		.50	†	.80	1.00	.800
		calc.	.33	.41	.51	.64	.80		
<i>Siobla excavata</i> Nort. 1897	F	act.	.35	.53		.90	1.30	1.60 2.10†	.762
		calc.	.41	.54	.71	.93	1.22	1.60	
<i>Pontania robusta</i> Marlatt 1897	F	act.	.35	.50	†	.70	1.00	1.30	.769
		calc.	.35	.45	.59	.77	1.00		
<i>P. pallicornis</i> Nort. 1897	F	act.	.20	.30	.40	.60	†	1.20	.667**
		calc.	.15	.23	.35	.53	.80		
<i>P. gracilis</i> Marlatt 1897	G	act.	.50	.70	.92†				.761
		calc.	.53	.70					
<i>Macrophya externa</i> Say 1898a	F	act.	.90	†	1.20	1.60	†	2.10 2.50	.840
		calc.	.87	1.03	1.23	1.47	1.76	2.10	
<i>Megaxyela major</i> Cress. 1898a	F	act.	.60	.80	†	1.20	†	1.80 2.20	.818
		calc.	.65	.80	.98	1.20	1.47	1.80	
<i>Nematus chloreus</i> Nort. 1898b	F	act.	.40	.60	.80	1.15	1.50†		.767
		calc.	.52	.68	.88	1.15			
<i>Hemichroa fraternalis</i> Nort. 1898b	F	act.	.40	.60	†	.90	1.30	1.70†	.765
		calc.	.44	.58	.76	.99	1.30		

TABLE III—Continued.

Species ¹⁰	Type of Measurement	Successive Larval Stages ¹¹								Ratio of Increase ¹²
<i>Periclista purpuridorsum</i> Dyar 1898b	F act. calc.	.60 .71	1.00 1.00	1.40						.714
<i>P. albicollis</i> Nort. 1898b	F act. calc.	.70 .68	† .86	1.10 1.10	1.40					.786
<i>P. media</i> Nort. 1898b	F act. calc.	.30 .33	.40 .42	† .53	.60 .68	.80 .86	1.10 1.10	1.40		.786
<i>Isodyctium subgregarium</i> Dyar 1898b	F act. calc.	.80 .80	1.20 1.20	1.80						.667
<i>Atomacera desmodii</i> Dyar 1900	F act. calc.	.60 .64	.80 .80	1.00						.800
<i>Pteronus ostryæ</i> Marlatt 1900	F act. calc.	.40 .46	† .57	.70 .70	† .86	1.00 1.06	1.30 1.30	1.60		.812
<i>Schizocerus zabriskiei</i> Ashm. 1900	M act. calc.	.25 .25	.35 .34	.50 .47	.65 .65	.90				.722

†In cases so marked, two measurements (the extremes of the range) were averaged.

†Inconsistencies are indicated here (not to be confused with a few stages which Dyar stated as missing). These 23 instances represent approximately 12 per cent of the number of comparisons made per instar. The following possibilities exist:

1. Dyar missed the stage and was unaware of it.
2. The measurement was inaccurate.
3. The larva measured was abnormal or exceptional, or simply exhibiting natural variation from an unknown mean.
4. Typically, the Rule does not hold—
 - a. With sawflies as a group.
 - b. With this particular species.
 - c. Except when averages of instar measurements are available.

¹⁰It has been found convenient to list the species just as given in Dyar's papers, without systematic arrangement, and making no nomenclatorial changes.

¹¹These data should not be taken as indicative of the number of instars for any species listed since, in a majority of cases, these data are incomplete in this respect, even for feeding instars.

¹²The Dyar ratio of increase is derived by the division of any actual measurement by the one of the stage immediately following it. In this table, the last (greatest) actual measurement is the divisor in every instance but one, which is marked ** and represents a division of the first measurement by the second to obtain this ratio. It has not been considered worth while, in these species, to obtain for comparison, the several ratios possible in each case.

DISCUSSION.

General value of Dyar's Rule.—Dyar's Rule has been discussed more or less critically by Ripley (1923), Peterson and Haeussler (1928), Calvert (1929), and others. Ripley, who used the reciprocal of Dyar's ratio, apparently found it useful in identifying instars of Noctuidæ but commented (pp. 38, 39) on "The inconstancy of Dyar's supposed constant . . ." as shown by the variation of the ratio, or "index of growth," within one generation of a given species (*i.e.*, if all the ratios possible in a series of instars of one species be obtained, these ratios very often are not identical) and also by the usually greater variation of the ratios when based upon comparable instars of different broods of the same species. Ripley points out, in addition, that these variations in general scarcely can be correlated with corresponding instars in different species. He says ". . . The variations in the index of growth for any species are of no uniformity, with the exception of the tendency toward largeness of the first [growth increase] and smallness of the last." Peterson and Haeussler found ratios for *Laspeyresia molesta* ranging from .57 to .61 in four-instar groups and from .63 to .75 in five-instar groups. Calvert (p. 260) questions the value of growth constants in Odonata or in other groups in estimates of the growth rate of different species and individuals. He says:

"Most of the determinations of rates of growth have had reference to units of time (days, months, weeks, or years), or to stages demarcated by moults. Temperatures, by increasing or decreasing the rate of growth, renders the time units so variable that they are often useless in comparing the growth of different species or individuals. Food or its absence, humidity and, in some cases, temperature affect the number of moults, as has been shown *antea*, so that these latter lose much of their significance as indicating definite points in growth. My colleague, Doctor R. L. King, has therefore suggested the advisability of . . . the plotting of definite fractions of the total growth against definite fractions of the time consumed in making that growth." [as others have done]. [This should give] ". . . a more equal basis of comparison of the growth rates of different species and individuals."

These authors have pointed out the limitations of Dyar's Rule or similar principles in comparative growth studies, specific growth rates, and allied research. They have not completely invalidated Dyar's Rule. The impression has been gained that Dyar's original concept of the use, or value, of this rule was merely that it would aid in the corroboration of, or the calculation of, the number of stadia. Nowhere in his paper

(1890) is it stated that a ratio for any species is invariable regardless of multiple generations, environmental changes, etc., nor does it seem that this, necessarily, is implied. On the other hand, the following statement by Dyar indicates that he appreciated the limitations of his rule:

" . . . If two sets of observations show a different number of stages for the same insect but each follows its own progression, we may conclude that this variation is actual; but if either set shows a lack of regular progression that one we must regard with suspicion."

Limited to the one use of checking the number of stadia—in certain groups only—and qualified as it must be to allow for variation of individuals within an instar and for cases where a molt is not followed by an increase in head size, Dyar's Rule still may serve its original purpose and prove useful, especially in the case of leaf-mining larvæ, the molts of which are difficult to detect and the exuvixæ of which may sift from the mine, and similar cases.

Value of Dyar's Rule when applied to sawfly larvæ and other groups.—In this paper, the primary concern has been to show that—in so far as it is reliable and may be useful—Dyar's Rule may be applied to sawfly larvæ, in general, as well as to lepidopterous larvæ. From the data presented in Table III, the agreement between calculated and actual head widths of the instars of 46 species of sawflies is at least as close and as consistent as in the 28 species of Lepidoptera upon which the criterion was based. In Table II, the agreement of the mean, and calculated mean, head widths of *Phyllotoma nemorata* is very close indeed. Theoretically, it would seem not illogical that Dyar's Rule might be applied successfully to still other groups of insects (or arthropods) provided a tendency toward similar growth phenomena—a size increase chiefly at the molts and a relatively static condition between ecdyses—is marked.

The danger of basing calculations on too few measurements has been demonstrated in the case of *Phyllotoma nemorata*. Table I shows the extent of individual variation within an instar where the head widths of the first four instars merge at their extremes. It seems not improbable that variation to this extent may occur in other species and that even cases of overlapping may be found. Because of this natural variation, which may be considerable in certain groups or under certain conditions, a head dimension of a single individual thus cannot be taken to typify that of its instar. On the other hand, the

mean dimensions of the head, when a reasonably large series is measured, are shown in Table II to characterize the several instars and thus may be employed in the utilization of Dyar's Rule. In general, it would seem unwise to apply this rule unless the basic data be refined by the employment of averages. It can be added that, in all cases where it is feasible to make direct observations throughout, it probably is not advisable to abandon this practice.

SUMMARY.

Dyar's so-called Rule—a generalization which probably need not be dignified by the term Law—which expresses a ratio of growth increase based upon the head measurements of successive larval instars, is described and the apparent restriction of this principle to Lepidoptera is discussed.

The application of Dyar's Rule to the birch leaf-mining sawfly, *Phyllotoma nemorata*, is presented. One hundred head widths of each of the seven instars of this insect are tabulated and these data, per instar, are analyzed in regard to range, modes, mean, calculated mean, Probable Error, and the like.

The agreement between mean, and calculated mean, head widths is very close; modes in each instar are marked; the range is sufficiently extensive so that the extremes of the first four instars tend to merge. The apparent usual lack of any increase in size in the head capsule of the last larval instar of sawflies is evident in this species. (Some notes on this and other characteristics of the prepupal stage of sawfly larvæ are given, chiefly in footnotes.)

Head measurements (based on an unknown number of individuals but probably very few, or but single, in each case) of instars of 46 species of sawflies described by Dyar are tested with his rule. It is shown that—even in this (Dyar's own) superficial manner—Dyar's generalization is upheld at least as well as by the 28 lepidopterous larvæ upon which the criterion was based.

Recent criticisms of Dyar's ratio in regard to its use as a constant in studies of growth, comparable growth, etc., are cited briefly and the general value of this rule, its limitations, and its original purpose are discussed.

The following conclusions are drawn:

1. With the restriction of its use to the corroboration of the number of instars observed, Dyar's Rule may continue to prove useful in certain groups.

2. In general, this rule holds as well with sawfly larvæ as with lepidopterous larvæ.

3. Theoretically, this principle should hold as well with any insect (or arthropod) provided marked increases in head size occur at the molts and only then.

4. This rule will be more reliable and may be utilized with more confidence if calculated head dimensions be determined from averages (which are based upon a sufficiently large number of measurements) per known instars.

5. Unless qualified as above, Dyar's Rule should not be employed, at least not without reservations.

6. In all cases where possible, it probably is not advisable to abandon direct observations.

BIBLIOGRAPHY.

(Reference preceded by an asterisk was not seen.)

- Calvert, Philip P. 1929. Different rates of growth among animals with special reference to the Odonata. *Proc. Amer. Ent. Soc.* 68: 227-274.
- Dyar, H. G. 1890. The number of molts in lepidopterous larvae. *Psyche* 5: 420-422.
1893. Descriptions of the larvae of certain Tenthredinidae. *Can. Ent.* 25: 244-248.
1894. Descriptions of the larvae of certain Tenthredinidae. *Can. Ent.* 26: 42-45, 185-189.
- 1895a. On the larvae of some nematoid and other sawflies from the northern Atlantic States. *Trans. Amer. Ent. Soc.* 22: 301-312.
- 1895b. (a) Descriptions of the larvae of certain Tenthredinidae; (b) The larvae of the North American sawflies. *Can. Ent.* 27: 191-196, 208-212, 337-344.
1896. Notes on sawfly larvae. *Can. Ent.* 28: 235-239.
1897. On the larvae of certain sawflies (Tenthredinidae). *Jour. N. Y. Ent. Soc.* 5: 18-30, 190-201.
- 1898a. Notes on some sawfly larvae, especially the Xyelidae. *Can. Ent.* 30: 173-176.
- 1898b. On the larvae of certain Nematinae and Blennocampinae, with descriptions of new species. *Jour. N. Y. Ent. Soc.* 6: 121-138.
1900. On the larvae of Atomacera and some other sawflies. *Jour. N. Y. Ent. Soc.* 8: 26-31.
- Horsfall, W. R. 1929. The grape-vine sawfly (Hym., Tenthredinidae). *Ent. News* 40: 174-177.
- Marlatt, C. L. 1890. The final molting of tenthredinid larvae. *Proc. Ent. Soc. Wash.* 2: 115-117.
- Middleton, William. 1923. The imported pine sawfly. *U. S. D. A. Dept. Bul.* 1182. 21 pp.
- Peterson, Alvah and Haussler, G. J. 1928. Some observations on the number of larval instars of the Oriental peach moth, *Laspeyresia molesta* Busck. *Jour. Ec. Ent.* 21: 843-852.
- Ripley, L. B. 1923. The external morphology and postembryology of noctuid larvae. *Ill. Biol. Monogr.* 8: 1-103 (inc. 8 pls.).
- Taylor, Raymond L. 1930. A simple statistical method for determining the approximate duration of the instars of leaf-mining larvae and others. *Jour. Ec. Ent.* 23: 587-595.
- *Wu, Chenfu Francis. 1923. Morphology, anatomy and ethology of *Nemoura*. *Bul. Lloyd Libr. No. 23* (Entom. Series No. 3), 1923. iv plus 61 pp., 16 pls.
- Yuasa, H. 1922. A classification of the larvae of the Tenthredinoidea. *Ill. Biol. Monogr.* 7: 1-172 pp. (inc. 14 pls.).

THE BIOLOGY OF BITTACUS STIGMATERUS SAY (MECOPTERA, BITTACUSIDÆ).*

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HISTORICAL ACCOUNT.

The genus *Bittacus* was erected in 1807 by Latreille in *Genera Crustaceorum et Insectorum*, for two European species, *italica* Muller and *tipularia* Linn., both of which had been formerly placed in the genus *Panorpa*. In 1823 the first American species of the new genus was described by Say in the *Western Quarterly Reporter*. This was *Bittacus stigmaterus*, the species to be considered in the present paper.

During the next half century many new species were made known to science. *B. mexicanus* (later found by Hine to be identical with *B. stigmaterus* Say) was described by Klug in *Abhandlugen der Academie der Wissenschaften zu Berlin* in 1836; *B. pilicornis*, *B. punctiger*, and *B. pallidipennis* (later found by Hagen to be synonymous with *B. stigmaterus* Say) were described by Westwood in the *Transactions of the Entomological Society of London* in 1841; *B. occidentis* was described by Walker in *The Catalogue of the British Museum* in 1853; *B. apicalis* Uhler and *B. strigosus* Hagen were made known in Hagen's *Synopsis of the Neuroptera of North America* in 1861: finally, *B. apterus* and *B. chlorostigma* were described in 1871 and 1881 respectively by McLachlan in the *Entomologist's Monthly Magazine*.

Nothing regarding the biology of any of these species was known before the time of Brauer, who may rightly be called the first great student of the genus. In 1863 he gave an admirable account of his observations on the habits and life history of the European species, *B. italicus* (and *B. hageni*). Yet nothing was known of a like nature regarding any of our American species.

In 1895 Felt in his paper entitled *The Scorpion-flies*, treating mainly the genus *Panorpa*, gave the first biological and morphological data known for our American species of *Bittacus*. In this work he described the feeding and egg-laying habits

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of *B. strigosus* (and *B. pilicornis*), but he states that the larval form remained unknown to him. In the same paper he illustrates several structures of the adult *B. strigosus*, including the fore tarsi and venation of the wings.

The next and only recent work of any kind was that of Hine in 1901. In his monograph of *The North American Species of Mecoptera North of Mexico*, he described and illustrated the male genitalia of all of our eight American species. A brief account of the structure of *B. strigosus* and a statement regarding the flying habits of *B. punctiger* and *B. pilicornis* are given by the same author.

The review of the literature shows how meager our biological knowledge is concerning any member of this genus. In spite of the fact that *B. stigmaterus* was the first American species to have been described, less is known regarding it than any other species. In fact, Hine's study of the wings and male genitalia constitutes our major knowledge of its morphology and actually nothing has been known of its biology.

SYSTEMATIC POSITION OF BITTACUS STIGMATERUS.

Comstock characterizes the Mecoptera as follows: The winged members of this order have four wings; these are usually long, narrow, membranous, and furnished with a considerable number of cross-veins; the wings are wanting or vestigial in two genera. The head is prolonged into a deflexed beak, at the end of which chewing mouth-parts are situated. The metamorphosis is complete.

PANORPIDÆ AND BITTACUSIDÆ.

The genus *Bittacus* was formerly included in the family Panorpidæ, but later Smith placed it in a separate family called the Bittacusidæ. Certainly the differences between the two groups are great enough to warrant this division. These differences may be outlined as follows:

Panorpidæ.

- Structure*.—(1) The tarsi are provided with two claws and are not fitted for grasping. (2) The last abdominal segment of the male is greatly enlarged. (3) The wings are spotted with black.
Biology.—(1) The adults sit on the surface of the foliage of plants when at rest. (2) The adults feed on dead or injured insects.

Bittacusidæ.

- Structure*.—(1) The tarsi are provided with a single claw and are fitted for grasping. (2) The last abdominal segment of the male is not greatly enlarged. (3) The wings are not conspicuously spotted with black.
Biology.—(1) The adults hang suspended by their front legs when at rest. (2) The adults normally feed on living insects which they have captured.

GENUS BITTACUS AND KEY TO THE AMERICAN SPECIES.

Hine gives the following description of the genus: The head is small, and largely occupied by the conspicuous compound eyes. The mandibles are widest at the base, and gradually narrowed distally, the distal end is curved and pointed and preceded by a sharp tooth. The maxillæ are peculiar in the large development of the maxillary palpi in comparison with the outer parts; the labium is short bearing two-jointed palps at its distal end. The legs are longer than the wings, which are ample and in most cases without conspicuous markings.

The same author gives the following key by which our eight American species of *Bittacus* may be identified:

- | | |
|---|---------------------|
| 1. Both sexes wingless | apterus |
| Both sexes with wings | 2 |
| 2. Hind femora and tibiae thickened, cross veins of wings (except <i>punctiger</i>) not margined | 3 |
| Hind femora slender, cross veins of the wings margined with fuscous | 6 |
| 3. Large dark colored species, pterostigma bright yellow | chlorostigma |
| Smaller species, pterostigma not bright yellow | 4 |
| 4. Wings at base, and hind femora with black punctate spots | punctiger |
| Wings at apex fuscous | apicalis |
| Wings and hind femora unmarked | 5 |
| 5. Male appendages not protruding beyond the last segment of the abdomen, rounded at the distal end | occidentis |
| Male appendages protruding beyond the last segment, turned inward at apex | stigmaterus |
| 6. Antennae with long pile, wings testaceous, with cross veins narrowly margined with fuscous | pilicornis |
| Antennae with short pile, wings pale, with the cross veins broadly margined with fuscous | strigosus |

Bittacus stigmaterus Say is described by Hine as follows: "Anterior wing, 18-21 mm, body, 16-18 mm. Light brown; ocelli surrounded by black, eyes black, rostrum and maxillary palps black, the pile on the antennæ is noticeably longer than in *occidentis*, veins of wings prominent, hind femora thickened, the outer of the two spines at the end of each hind tibia as long as the first tarsal joint. Male appendages, from side view, oblong, superior edge strongly elevated at base, nearly straight to apex, inferior edge very gradually approaching the superior, thus making the apex slightly narrower than the base, length of the appendage about 2 mm."

The popular name "scorpion-flies" has been applied to the members of the genus *Panorpa* because of the enlarged forcep-like claspers of the male. Some writers and teachers of entomology appear to include the members of the genus *Bittacus* under the same term, though the male appendages have no likeness whatever to those of a scorpion. This is, as Dr. Felt has stated, perhaps due to the lack of a more appropriate common name. For non-technical purposes, I would suggest that the members of this genus be called "hanging-flies." Certainly, hanging is a habit peculiar to these insects and hence may rightly be used. The term will be employed throughout the present paper.

DISTRIBUTION.

Species of *Bittacus* occur both in Europe and in America. Some of our species have a wide distribution, but others have never been collected beyond the limits of a single state. Thus *B. strigosus* occurs in nearly all of the eastern half of the United States, extending westward as far as Kansas, while *B. chlorostigma* and *B. apterus* are found only in certain parts of California. *B. stigmaterus* has been collected in the following states: New York, Ohio, Illinois, Maryland, Virginia, Georgia, Missouri, and Kansas. Moreover, within the last state named, it is known to occur in the following counties: Riley, Montgomery, Smith, Rooks, Osborne, Lyon, and Douglas. Indeed, Roger C. Smith lists *B. stigmaterus* among the most common species of *Bittacus* found in Kansas.

HABITAT.

The home of *Bittacus stigmaterus* is the moist, shady woodland, out of the reach of the sun's rays. Here the hanging-flies suspend themselves by their long slender fore limbs to the lower branches of shrubs and weeds. Such a position is seldom over a few inches above the surface of the ground, but occasionally some have been observed in rank growths of buck brush, *Symphoricarpus orbiculatus*, at a higher distance (two or three feet).

Once a place is found in which these insects occur, there they may be found from year to year, generally in great numbers. A farm near Lawrence, Kansas, has for many years been a fertile place for hanging-flies. Here they make their appearance in early July and remain until September in apparently never-decreasing numbers. It is of much interest to note that we have found that two species occur here within an area which is less than one hundred feet square. During the first part of July, *B. strigosus* is the common and, in fact, the only species for a time. But by August and September it is no longer to be found. *B. stigmaterus* has appeared and become the dominant form in the very place where *B. strigosus* once thrived. This change takes place gradually. Hence, *B. strigosus* may be termed an early occurring species and *B. stigmaterus* a late occurring one.

Furthermore, I have observed that *B. stigmaterus* gradually collects in the damper part of the woodland with the advance of summer. It is a common thing in late August to find many of these insects assembled among the clumps of grasses and other plants near the very edge of a shaded pool or stream. In such places there are generally swarms of many kinds of dipterous insects, furnishing a generous supply of food for the hanging-flies.

HABITS OF THE ADULT.

FLIGHT.

Bittacus stigmaterus seldom flies, except when disturbed or when torn from its support by its resisting prey. Even when these few flights are made they are for only a short distance, seldom over two or three

feet at a time, and just barely above the top of the dense herbage. In fact, the long, slender spiny legs often are caught upon the foliage, causing the flight of the insect to appear stumbling and awkward.

When the hanging-flies are disturbed by the collector, great numbers of them may often be seen flying just a few feet ahead of him as he walks along slowly through the thick herbage. In this way I have been able to drive large numbers of them into a single nook or corner of the woods.

In the laboratory I have seen them fly about carrying their prey with them by means of their hind tarsi, but none while on wing have been observed to attempt to catch prey. Some individuals in the laboratory which had escaped from my cages have been found to fly to a height of eight feet.

WAITING FOR PREY.

The hanging-flies do not sit upon the surface of the foliage of plants, but hang suspended by their front legs from some branch or leaf. Very often one leg or the other of the middle pair assists in this hanging position. In their suspended position the front pair of legs are bent so that the head is elevated somewhat above the fore femora, thus allowing the head to be freely moved from side to side. The two middle legs are generally extended in front and slightly outward on each side. Likewise, the two hind legs are protruded in front of the body but at a lower level. Thus the whole makes a circular trap of dangling legs for the unwary prey. I have seen *B. stigmaterus* hang quietly for hours in such a position waiting for its food.

FEEDING.

Bittacus stigmaterus is a typical predacious insect. In its ability to capture prey it equals, if it does not excel, the preying mantis. The slender dangling legs remain perfectly motionless until a fly or some other insect is well within their reach, even at times allowing the insect to fly through the trap once or twice unmolested. But suddenly the armed tarsi seize the unfortunate passer. Often *B. stigmaterus* is actually torn from its support when the captive struggles for its life; yet the hold is seldom relinquished. The fourth and fifth hind tarsal segments are generally securely coiled about the base of the fluttering wings. Then the victim is lifted to the mouth and only the soft parts and body fluids are eaten, hence nearly all of the prey's body is left after feeding. But fifteen or twenty minutes is required for the completion of a meal, at the end of which time the lifeless remains are dropped upon the ground. (*B. stigmaterus* has been observed to continue its chewing movements for some little time after feeding.)

I have found this species to eat nothing but living insects. All of the following have been eaten by my caged specimens:

House-flies, *Musca domestica*.

Pomace-flies, *Drosophilidæ*.

Crane-flies, *Tipulidæ* (some species of which were larger than *B. stigmaterus*).

Long-legged flies, *Dolichopodidæ*.

Mosquitoes, *Culex*.

These insects are also cannibalistic. I found one individual feeding upon one of its comrades when there was no other food provided.

B. stigmaterus requires a considerable amount of food; in fact, some of my caged specimens could have eaten more food than I had for them. I have observed several individuals seize as many as three *Drosophilid* flies at a single time, one being held by each of the hind feet and one by a middle leg. Ninety of these small pomace-flies were devoured by a single *Bittacus* in less than two days. One female ate eighteen house-flies in a single day, while another ate thirty-two in two days. Further information regarding the amount of food eaten by a single individual per day may be obtained from the following table:

CAGE NO.	SEX	KIND OF INSECTS EATEN	NO. OF INSECTS EATEN
1...	Female.....	<i>Drosophilidæ</i>	5
2...	Female.....	<i>Drosophilidæ</i>	12
3...	Male.....	<i>Drosophilidæ</i>	10
4...	Female.....	<i>Drosophilidæ</i>	32
5...	Male.....	<i>Drosophilidæ</i>	30
6...	Male.....	<i>Dolichopodidæ</i>	3
7...	Female.....	<i>Dolichopodidæ</i> , 5.....	9
		<i>Drosophilidæ</i> , 4.....	
8...	Female.....	<i>Drosophilidæ</i>	20
9...	Female.....	<i>Dolichopodidæ</i> , 6.....	9
		<i>Drosophilidæ</i> , 3.....	
10.....	Female.....	<i>Musca domestica</i>	18
11.....	Female.....	<i>Dolichopodidæ</i> , 8.....	15
		<i>Culex</i> , 7.....	
12.....	Female.....	<i>Drosophilidæ</i>	11
13.....	Female.....	<i>Dolichopodidæ</i> , 5.....	8
		<i>Culex</i> , 3.....	
14.....	Female.....	<i>Drosophilidæ</i>	4
15...	Female.....	<i>Dolichopodidæ</i> , 7.....	11
		<i>Culex</i> , 4.....	

Although the hanging-flies will eat almost any small insect which might fly around near them, they have a preference for the Diptera. The time required to eat a single fly was found to be quite variable. One female required 40 minutes, while another needed 50 minutes to eat the soft parts and suck the body fluids of a house-fly. These two cases were the longest periods required according to our observations. The average time was about 20 minutes.

CLEANING UP.

Following each feeding, the hanging-fly performs its toilet. This I have found to be true for both *Bittacus strigosus* and *Bittacus stigmaterus*. Furthermore, careful observation has shown that the "cleaning up" habit may be divided into some half dozen more or less definite steps. For *Bittacus stigmaterus* these are as follows:

(1) Both the hind and middle pair of legs are extended forward making an angle of approximately forty-five degrees with the under side of the abdomen. Then a single middle leg is drawn back and forth between the hind legs which remain extended and held tightly together. Often the hind legs are braced in their extended position upon an adjacent twig, instead of being held in a free position.

This first step in the "cleaning up" process is invariably repeated many times in succession. Moreover, the leg used in the rasping movement is alternated with the opposite leg of the same pair from time to time.

(2) A single middle leg is raised in such a position that the mouth parts, head, and neck are easily wiped upon the lifted femur. Again, a single wiping is not sufficient, a number of repetitions is necessary. But there is seldom an alternation with the opposite leg in this case.

(3) The leg just used as a wiper for the head region is returned to the normal position and is drawn a number of times through the tightly extended hind pair of legs in much the same fashion as in the first step. However, the movable leg in this procedure is frequently simply raked upon the spiny sides of any one of the extended legs.

(4) Sometimes step (2) is repeated and followed by a repetition of step (3). The same leg that was used before, or the opposite leg of the same pair may be employed.

(5) Both a fore and hind wing are extended side by side in front of the body. In this position they are held between the tarsi of the hind and middle legs of the same side. Then these tarsi are slowly raked upon the outer surface of the contiguous wings.

In the concluding of this step the hind legs cease to serve as rasping organs, but have as their function merely that of holding the wings in position while the tarsus of a leg on the opposite side is scraped along the free margins of the wings. After this has been done two or three times, the wings are allowed to return to their normal position.

(6) Finally, the whole abdomen is lifted to a position where it is easily brushed on both sides by the hind femora. Several strokes made by these organs conclude a complete "cleaning up."

The description just outlined is in the main followed by hanging-flies of this species. But occasionally individuals have been observed to deviate from the normal procedure. For example, I have seen the extended tarsi worked against each other immediately following step (5) and before step (6) was undertaken. Furthermore, it is well to note the toilet may be discontinued at any time if the insect should be disturbed or if its prey should come near during the process. But if no distractions of any sort occur, the "cleaning up" may be repeated several times.

It should also be mentioned that the insect will brush the long legs, one upon the other, even though no food has ever been eaten. This fact has been demonstrated by newly emerged adults not provided with any food.

MATING.

Brauer gives the following account of his observations of the mating habits of *B. italicus*: "While the female is feeding a male appears sooner or later and mating occurs. In the process both sexes hang with their ventral sides together. Copulation may require hours, but often it is done in a short time. The male does not die immediately, but often seeks out another mate." The writer has not yet been successful in observing the copulation of hanging-flies either in the field or in the laboratory.

EGG LAYING.

My first observation (August 20, 1929) on the oviposition of *Bittacus stigmaterus* is characteristic:

I.

The cage was taken from a semi-lighted room at 9:00 P. M.

Three eggs, which had but recently been laid, lay upon the bottom of the cage.

The adult was found with the end of her beak resting firmly against the bottom of the cage and with her long legs held out on both sides of the body in a supporting fashion.

The abdomen was lifted some distance from the bottom of the cage. It was held in a rigid position, except for a slight muscular movement which was apparently an effort to work the egg out of the body. Even when completely exposed the egg hung at the tip of the abdomen and did not drop upon the floor of the cage until she made a sudden jerk with her wings.

II.

She then flew up and took a new position only a few inches distant.

She assumed the same position as before, except for the fact that the wings were fully extended this time in a horizontal position.

In about 15 minutes she deposited another egg in much the same manner as before. Again, the egg remained for a time at the posterior end of the body and required a quick jerk of the wings to loosen its hold.

III.

Without moving to a new position she laid a third egg within less than 10 minutes.

She did not hold the wings extended this time. Furthermore, the egg fell upon the bottom of the cage without any special movement of the wings.

This individual deposited a total of 17 eggs in less than 2 hours.

From all observations made on the egg-laying habits of *B. stigmaterus*, we are led to conclude that the eggs are laid singly and at random over the surface of the ground. Moreover, we have found that a single female may deposit eggs at various intervals throughout her life time.

The exact number of eggs laid by different individuals has been found to be quite variable. One female laid 60 eggs in 5 days; others

have laid but 1 or 2 eggs in the same length of time. A very accurate record concerning the production of eggs by *B. stigmaterus* (each cage contained a single female) is given in the following table:

Cage No.	Number of Days	Number of Eggs Laid	Cage No.	Number of Days	Number of Eggs Laid	Cage No.	Number of Days	Number of Eggs Laid
1	5	60	21	1	4	41	1	1
2	1	5	22	1	3	42	1	11
3	5	44	23	4	49	43	1	14
4	1	4	24	1	4	44	1	3
5	1	8	25	4	25	45	2½	5
6	4	3	26	1	5	46	1	12
7	1	5	27	1	4	47	3	26
8	1	2	28	1	9	48	1	4
9	1	15	29	3	0	49	2½	0
10	4	2	30	1	12	50	1	1
11	1	1	31	2½	0	51	1	21
12	3	7	32	1	6	52	2½	0
13	1	9	33	1	1	53	2½	1
14	3	1	34	2½	6	54	1	2
15	1	7	35	1	4	55	1	0
16	1	12	36	1	0	56	1½	10
17	1	10	37	1	6	57	1½	14
18	3	1	38	1	3	58	1½	0
19	1	19	39	2½	0	59	1½	4
20	5	8	40	1	4	60	1	2

LIFE HISTORY.

THE EGG.

Eggs of *Bittacus stigmaterus* are laid during the summer months from July to September, and remain unhatched throughout the winter. That the egg is the overwintering stage has been definitely proved. I have had in my possession over 900 eggs, all of which passed the winter in a perfect condition.

The egg of *B. stigmaterus* is indeed peculiar. It is rectangular in shape, and each of the six surfaces bears a central depression. It has a thick, hard leathery shell. The outer surface is very rough, in fact, under the compound microscope it appears to be a mass of various sized spherical granules. This outer shell is dark brown in color, though some eggs of a lighter color have been found. To the naked eye it appears to be but a particle of soil. The dimensions of a newly-laid egg are approximately .6 mm. x .5 mm. x .5 mm. See the accompanying illustrations of both a side and end view of an egg of *B. stigmaterus*, Figs. 1 and 2.

I have found that moisture must be provided if the eggs are to hatch. All of the 150 larvæ of *B. stigmaterus* which I have seen were hatched from eggs that had been provided daily with moisture for two or three weeks previous to the time of hatching. And no eggs while entirely dry have been known to hatch. These findings cor-

respond very closely to those obtained by Brauer in 1865 for *B. italicus*. This work on the European species is stated by Packard as follows: "And now a remarkable fact has been noticed by Brauer. He has observed that if the marshy or wet ground, where the female *Bittaci* customarily lay their eggs, does not dry up, no females appear until the second year following; so that the eggs lie over unhatched two years. The first condition of their hatching is a complete drying of the earth in which the eggs lie; the second condition is a succeeding thorough wetting of the ground in the spring. If the ground remains dry from want of snow in the winter, or rain in the spring, and there follows in the next summer a very thorough wetting of the soil, then the time of appearance of the adults will be retarded three or four months."

Freezing does not seem to be essential for hatching. Eggs kept in-doors during the winter hatched as well as those which were kept outside.

I have observed the eggs of *B. stigmaterus* in every case to begin to enlarge about a week or ten days before hatching and continue to do so until surprisingly large proportions are reached before the larva leaves the egg. The largest diameter of the newly laid egg is only .6 mm. but that of the egg before hatching is 1.1 mm. During the period of incubation the egg loses its rectangular shape and assumes a perfect spherical form.

The larva leaves the egg through an irregular opening cut through the tough leathery shell. Fig. 3.

The table given below shows the duration of the egg stage. Although this applies to but a very few of the eggs incubated in the laboratory it is typical for the species.

DATE OF LAYING	DATE OF HATCHING	TOTAL NUMBER OF DAYS IN EGG STAGE
July 28, 1929	March 7, 1930	222
July 25, 1929	February 26, 1930	216
July 30, 1929	March 12, 1930	225
July 29, 1929	March 8, 1930	222
July 25, 1929	March 2, 1930	220
July 27, 1929	March 5, 1930	221
July 28, 1929	March 9, 1930	224
July 26, 1929	March 7, 1930	224
July 29, 1929	March 11, 1930	225
July 28, 1929	March 6, 1930	221
July 29, 1929	March 16, 1930	230
August 3, 1929	April 3, 1930	243
July 19, 1929	April 1, 1930	256
August 6, 1929	March 25, 1930	231
July 27, 1929	March 9, 1930	225
July 27, 1929	March 11, 1930	227
July 25, 1929	March 12, 1930	230
July 26, 1929	March 12, 1930	229
August 17, 1929	March 28, 1930	223
July 29, 1929	March 6, 1930	220

The first larvæ of *Bittacus stigmaterus* to be seen by us hatched on September 21, 1929 from an egg laid July 25, 1929. This rapid development is not the normal occurrence, but is recorded here to show that exceptions to the normal development do occur.

THE LARVA.

Structural Description—The larva of *Bittacus stigmaterus* is cylindrical with a rounded head. On the dorsal side it is adorned with two prominent rows of spines (except on the first and last segments) each of which bear a long terminal whip in addition to a pair of distinct knobs near the base. But the spines on the eighth and ninth abdominal segments are different in that they lack the long terminal whip and bear three basal knobs instead of just two. The tenth segment bears a single spine similar to those on the two preceding segments but it is entirely lacking in any basal knob. The first thoracic segment is peculiar in that it is furnished with six spines bearing terminal whips but all of these point forward forming a collar-like structure about the base of the head. Fig. 4.

Both sides of the body are provided with a single row of spines much like those on the dorsal side, except for their smaller size. Here, again, the first thoracic segment and the last three abdominal segments are different from the rest. This segment of the thorax possesses no spines. The ninth and tenth abdominal segments bear a single spine-like hair. Just above the base of each lateral spine is a single seta on each segment.

On the lateral margin of the ventral side of the abdominal segments (except the tenth segment which will be described separately) is a row of spines. On each segment it consists of three bristle or hair-like spines of which the middle one is longer than the other two. Each of these nine abdominal segments bear a pair of short median prolegs on each side of which is a single short spine. Fig. 6.

The ventral side of the last or tenth abdominal segment is very interesting for it is provided with a very efficient posterior sucker which is used as an aid in locomotion. This is shown fully extended both from a lateral and a ventral view in Figs. 8 and 9. The surface of this posterior segment is comparatively smooth except for a few short scattered spines and two longer ones on its lateral margins above the sucker.

The three thoracic segments bear on their ventral surface a pair of prominent legs. These legs are fairly sharply pointed and are furnished near their basal segments with a few scattered spines.

The head is rounded at the vertex and is normally so completely bent under the body as to be entirely hidden by the thorax when viewed from above. There is a single median ocellus on top of the head. There are two larger eyes, one borne on each side of the head near the base of the antennæ. These are not true compound eyes but are simply a group of several ocelli. The antennæ are prominent, stout, two-segmented structures. The mandibles are large and heavily chitinized. Collectively the mouth parts give the front of the face a

wedge-shaped appearance. The entire head is clothed with short spines arranged in a definite fashion as shown in the accompanying illustration Fig. 6.

In the newly hatched larva the thorax and abdomen are light gray in color; the head, which is then always a more conspicuous structure than later, is dark brown. In the older larva the cuticula of the entire body becomes a slate-gray color and is very warty in appearance, for the small particles of sand and sediment adhere to the outer surface. The older larvæ differ from the young larvæ not only in being darker colored and having a relatively smaller sized head, but also their long whip-like dorsal spines are not distinctly knobbed.*

Larval Habits.—The young larvæ upon hatching from the egg escape from an irregular opening made in the wall. They feed upon their own egg shell, in most cases devouring it completely, but in many cases they do not. At this early age they are very active and wander around apparently in search of food. All of my 150 larvæ were fed very small pieces of fresh beef steak which they ate fairly well, especially while they were quite small. But the older larvæ seemed to prefer to bury their heads in the soil or about the roots of moss plants which I would provide. A few of these older larvæ have been actually observed to chew at pieces of dead moss roots and even tender green blades of grass. Since the older larvæ are very sluggish in their movements over the surface of the soil and seldom move unless disturbed they undoubtedly do not capture living prey. As a further proof of this, many small living earthworms, crustaceans, and insects were provided but all were refused.

The very young larvæ have the interesting habit, when disturbed, of standing almost perpendicularly on the posterior end of the body with the head and thorax coiled under the ventral side of the body. The young as well as the older larvæ feign death for a considerable length of time.

On molting, the head is a shiny light brown and the thorax and abdomen are a semi-transparent grayish color. The larva at once feeds upon the skin as soon as shed. For this reason it was quite difficult to determine the number of molts with any accuracy.

In about one month my larvæ entered the soil through a characteristic opening made by them. This is shown in the accompanying illustration. Fig. 7.

The rate of growth for one was as follows:

*Brauer (1865) after observing the European species *B. italicus* for twelve years, found only six larvæ, all of which died at the end of twenty days. His description of the larvæ of this foreign species corresponds in general to that here given for the American, *B. stigmaterus*.

LARVA No. 1.

EGG HATCHED MARCH 13, 1930.

Date	Length of Body in mm.	Width of Body in mm.	Date	Length of Body in mm.	Width of Body in mm.
March 13.....	2.55	.43	March 29....	7.23	1.91
March 14.....	2.98	.43	March 30....	7.65	1.91
March 15.....	2.98	.64	March 31....	8.08	2.13
March 16.....	2.98	.64	April 1.....	8.50	2.13
March 17.....	3.19	.64	April 2.....	8.93	2.34
March 18.....	3.40	.64	April 3.....	9.35	2.34
March 19.....	3.40	.64	April 4.....	9.35	2.34
March 20.....	3.83	.85	April 5.....	9.35	2.34
March 21.....	4.25	.85	April 6.....	10.08	2.55
March 22.....	4.47	1.06	April 7.....	10.41	2.55
March 23.....	4.66	1.06	April 8.....	11.00	2.96
March 24.....	5.10	1.28	April 9.....	11.48	3.19
March 25.....	5.53	1.49	April 10....	11.90	3.40
March 26.....	5.95	1.46	April 11....	11.90	3.40
March 27.....	6.38	1.70	April 12.....	(Went into the soil)	
March 28.....	6.80	1.70			

The length was determined when the larva was extended its full length ready to move; the width was taken from tip of one dorsal spine (not including the hair-like whip) to the tip of the other.

Five other larvæ spent 26 days each in the larval stage, one spent 28 days, and another took 36. All these were kept in the laboratory at house temperature.

The largest larva became 13.90 mm. long.

THE PUPA.

Nowhere in the literature available is there any record of the pupal stage of any species of *Bittacus*, either American or European. Brauer's six larvæ of the European species *B. italicus* died before pupating, and Felt states that even the larva of the American species *B. strigosus* remained unknown to him. Hence, the many pupæ of *B. stigmaterus* which I obtained in the laboratory during the month of April, 1930, seem to be the first to be seen for any species of *Bittacus*.

The Pupal Cell.—As already mentioned, the full grown larva enters the soil by way of an opening of its own construction. This entrance is circular and surrounded by a nicely constructed ridge made of particles of earth mixed with saliva. It resembles a miniature opening of a crayfish burrow. From this there leads a short circular tunnel to the oblong pupal cell itself. This subterranean cell is also circular but of a larger diameter than that of the entrance. Fig. 10.

Here, inside the cell, the larva molts. The molted skin of the larva may readily be found at the extreme end of the earthen chamber.

Description of the Pupa.—The pupa of *Bittacus stigmaterus* is exarate, that is, the appendages are free. Fig. 11. The head is held tightly

against the ventral side of the body and the antennæ lie closely against the dorsal side of the thorax. The femur of each front leg is likewise held closely against the side of the thorax and extends upward at approximately a forty-five degree angle, with the remaining segments bent ventrad to the abdomen. The middle pair of legs assume a position quite similar to that of the front pair. The femur of each of the hind legs extends downward at an angle of forty-five degrees on either side of the abdomen with the tibia bent forward and lying closely appressed against the full length of the femur. The hind tarsi meet on the ventral side of the abdomen as do those of the other two pairs of legs. The delicate wings are also held closely against the sides of the body but have their apices extending considerably forward, thus protecting the tarsi. The abdominal segments are exposed on their dorsal side. They are larger and furnished with setæ arranged in characteristic fashion as shown in the illustration. The pupa is of a uniform gray or brownish-white color, except the large compound eyes, which are dark brown.

The pupal stage lasts a little longer than two weeks. The following table gives the duration of the pupa for ten individuals reared in the laboratory.

DATE LARVA ENTERED THE SOIL	DATE ADULT EMERGED	TOTAL DAYS FOR PUPAL STAGE
April 15.....	April 30.....	15
April 12.....	April 29.....	17
April 17.....	May 2.....	15
April 2.....	April 17.....	15
April 11.....	May 1.....	20
April 6.....	April 23.....	17
April 12.....	April 30.....	18
April 11.....	April 30.....	19
April 13.....	May 1.....	18
April 2.....	April 17.....	15

THE ADULT.

The adult hanging-fly emerges from the soil by way of the opening through which the larva entered. The cast skin of the pupa is always left projecting from the opening. The new imago is at first light colored but it becomes the normal color in about a quarter of an hour.

The adults make their appearance about the middle of July and disappear by the first of September. However, I have collected a few specimens as late as September 12, but certainly this is very unusual in this part of the state.

The life of a single adult is doubtlessly short. The length of life of individuals in captivity varied from 1 to 7 days. Only two, one male and one female, out of over 100 specimens have been known by us to live over 7 days.

That the females do not live as long as the males under the same conditions is evident from the following table of the record of twenty-eight cages, each cage containing one male and one female.

CAGE NO.	DURATION IN DAYS	FEMALE	MALE
1	3	Dead	Living
2	1	Dead	Living
3	6	Dead	Living
4	1	Living	Dead
5	1	Dead	Living
6	1	Dead	Living
7	1	Living	Dead
8	1	Dead	Living
9	3	Dead	Living
10	1	Living	Dead
11	1	Dead	Living
12	6	Dead	Living
13	1	Dead	Living
14	3	Dead	Living
15	1	Dead	Living
16	1	Dead	Living
17	3	Dead	Living
18	1	Dead	Living
19	1	Dead	Living
20	3	Dead	Living
21	3	Living	Dead
22	1	Dead	Living
23	1	Dead	Living
24	1	Dead	Living
25	1	Living	Dead
26	1	Dead	Living
27	6	Dead	Living
28	3	Dead	Living

In concluding this account of the life history of *Bittacus stigmaterus*, it is well to summarize the time required for each stage of the metamorphosis. For one of the first individuals to be reared in the laboratory it is as follows:

COMPLETE LIFE HISTORY OF A SINGLE HANGING-FLY, *B. Stigmaterus*.

STAGE	DATE	TOTAL DAYS
Egg	July 28, 1929—March 6, 1930	221
Larva	March 6, 1930—April 1, 1930	26
Pupa	April 2, 1930—April 17, 1930	15
Adult	April 17, 1930—April 22, 1930	5

It was also found that the average time required for the different stages was as follows:

Egg	226 days
Larva	28 days
Pupa	16 days
Adult	5 days

NATURAL ENEMIES.

True it is, that the hanging-fly imperils the life of many insects even larger than itself. Nevertheless, certain species of the family Asilidæ are able to terrorize the life of *Bittacus*. These robber-flies have been frequently observed flying about over areas inhabited by *Bittacus stigmaterus* and I have seen them fly through the air carrying the lifeless remains of hanging-flies.

Furthermore, there are certain little red mites that occasionally attack *B. stigmaterus*. In spite of the frequent toilets made by its host, these creatures are able to adhere to a femur or some other part of the body.

MODIFICATION OF THE LEGS.

No other insect is known that can use its hind legs to capture its prey. This adaptation is peculiar to the genus *Bittacus*. Such a use of the hind pair of legs would seem to be very awkward, but anyone who has seen these insects feeding would testify quite to the contrary. This efficiency, however, has been gained at the expense of the ability to use these structures as a means of locomotion. The hanging-fly cannot walk or even support the body on its long legs in the ordinary way. If several individuals be placed in a small box their long legs become entangled into a helpless mass.

TECHNIQUE.

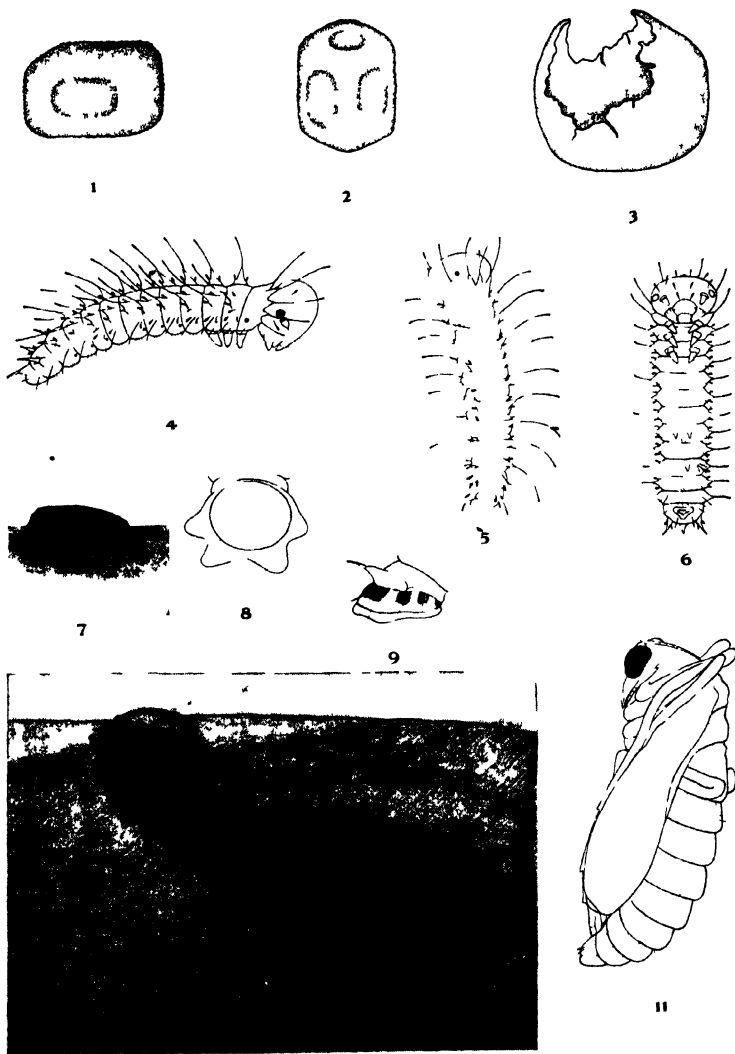
COLLECTING SPECIMENS.

The adult insects used in my experiments were taken from a farm near Lawrence, Kansas, and one near Emporia, Kansas. The instrument used for collecting was simply a large lamp chimney, the top end of which was closed with a piece of cheese cloth held in place by a rubber band. By holding this at the top end, the large basal opening was quickly thrust over the insect as it hung quietly from some support. Then by holding the palm of my hand over the opening the captive was carried to a wooden box about 18" x 16" x 12", provided with several twigs to serve as supports for the insects, and furnished at one end with a closeable opening about the size of the base of the lamp chimney. When the opening of the chimney was placed against that of the box the hanging-fly was allowed to enter the container.

An ordinary insect net was not found to be satisfactory in the collecting of these insects. Many individuals were injured either by the sweeping of the grass or on being removed from the net.

THE CAGES.

The ordinary Mason glass fruit jar was found to be very satisfactory for individual cages or even for a single pair of these insects. The mouth of the jar was covered with a small piece of cheese cloth held in place by a rubber band. Each jar was provided with a small twig on which one or two insects might hang. Such cages were advantageous



- | | |
|---|-----------------------------------|
| 1. Side view of egg | 6. Ventral view of larva. |
| 2. End view of egg | 7. Mouth of pupal cell. |
| 3. Egg shell after hatching, showing enlargement of egg | 8. Ventral view of larval sucker |
| 4. Lateral view of larva | 9. Lateral view of larval sucker. |
| 5. Dorsal view of larva | 10. Section through pupal cell. |
| | 11. Pupa. |

for the following reasons: (1) they were convenient to handle; (2) the hanging-flies seemed to be more satisfied in this sort of cage than in any other tried by us; (3) the insects could be easily transferred from one jar to another; (4) the eggs were readily collected by simply inverting the jar; and (5) small flies and other insects placed in the jar for food could not escape.

All cages were kept upon a table in a basement room near a large container of water, thus providing the necessary shade and moisture.

PROVIDING FOOD.

In order to have a sufficient food supply of living insects for the hanging-flies, it was necessary for me to raise pomace-flies, *Drosophila*. This was done by allowing them to breed upon pieces of ripe banana in fruit jars. To introduce a fresh food supply into a cage, I simply inverted a hanging-fly jar over one swarming with *Drosophilid* flies.

CARE OF THE EGGS, LARVÆ, AND PUPÆ.

The most convenient containers for keeping the eggs were small flower pot saucers lined with moist cellu-cotton over each of which the flower pot itself was inverted. By adding a small amount of water each day, the eggs were kept moist.

After hatching, each larva was transferred to a similar container in which a small amount of soil and moss were placed upon the cellu cotton. Moisture and tiny pieces of beef steak were provided daily, to these containers.

When the larvæ had entered the soil to pupate less moisture was provided.

A QUANTITATIVE STUDY OF COPPER IN INSECTS.*

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Although considerable data have been accumulated regarding the quantity of copper in marine organisms (9), mammalian blood, (3), (5), milk (4), (10), and plant and animal foods, (2), (6), little is known regarding the quantity of copper in insects.

Muttkowski (7), (8) showed that copper was present in certain insects and in insect blood in quantities comparable to that present in the blood of crayfish, (*Cambarus* sp.). Since the amount of copper present in the crayfish blood was not given the above works possess but little quantitative value.

The purpose of this paper is to present the results of a quantitative study of copper in insects.

METHODS.

Extremely accurate quantitative studies on the copper content of insects necessitated the purification of all reagents employed in making such determination since traces of copper are commonly present in high-grade chemicals, even those marked, "C. P." Furthermore, ordinary distilled water quite often contains more copper than tap water. The water used in the preparation of reagents and final washing of all glassware was double distilled in pyrex. This still was constructed by sealing a 30-inch arm onto a 2-liter pyrex Claisen flask. The advantages of such an arrangement lie in the fact that it is pyrex throughout, no rubber connections or the like, and that the possibility of contamination due to spray is minimized.

The apparatus described above was also employed in the purification of nitric acid.

The ammonia produced by dropping ammonium hydroxide upon solid sodium hydroxide was passed into copper free water,

*The author wishes to express his indebtedness to Mr. L. Goodhue, Chemistry Department, Iowa State College, for suggestions and criticisms during the course of the work.

in an ice bath, to give copper free ammonium hydroxide. In like manner, hydrochloric gas, liberated by the dehydration action of sulphuric acid on hydrochloric acid, was passed into water to give the copper free hydrochloric acid.

Copper determinations were made colorimetrically by the use of sodium diethyl dithio carbamate, $(C_2H_5)_2NCSS Na$. This reagent was first employed in the determination of copper by Callan and Henderson (1). 0.1% aqueous solution of this compound in the presence of copper gives a golden brown color. At a dilution of 1 part copper per 50 million of water a definite color is produced which is stable for more than an hour. Another distinct advantage of this reagent is that the reaction is the same in acid, neutral or alkaline solution. However, members of the iron-zinc group interfere and must be removed.

A stock copper solution containing 1 mg. copper per cc. was made by dissolving 3.9283 g. of $CuSO_4 \cdot 5H_2O$ in water to make 1 liter. The standard copper solution containing 0.01 mg. copper per cc. was prepared by diluting 10 cc. of the stock solution (1 mg. per cc.) to 1,000 cc.

The steps in the analysis are enumerated below:

- I. Weights, both fresh and dry.*
- II. Digested in conc. nitric acid and evaporated to dryness.
- III. Ashed to a white ash in a muffle furnace at a dull red heat.
- IV. Ash taken up in conc. hydrochloric acid; made ammoniacal and filtered.
- V. Filtrate made to 50 cc.
- VI. Five or 10 cc. of the above solution is pipetted into a 50 cc. Nessler tube; 10 cc. of 0.1% sodium diethyl dithio carbamate solution added and water to mark. Shaken.
- VII. A "known" is prepared by adding 5 cc. ammonium hydroxide, 10 cc. of sodium diethyl dithio carbamate solution to a 50 cc. Nessler tube; water to mark. Shaken. By means of a micro-pipette standard copper solution (0.01 mg. per cc.) is added until the color in the "known" matches that of the unknown. In the event that the sample contains only minute traces of copper, a "known" containing 0.03 mg. copper is prepared and copper added to the unknown until its color matches that of the "known."
- VIII. Calculations.

Although some 600 copper determinations were made only those determinations in which the original weight of the sample was 5 g. or more are considered in this report. Some results of this study are tabulated in Table I.

*The material was dried in an electric oven at about 71° C. for 24 hours.

DISCUSSION

In comparing the copper content of insects (Table I) with that of certain foods, (2), (6), it is evident that certain insects accumulate copper, e.g. the copper content of certain grain eating insects is higher than that of the food on which they live.

TABLE I.

Showing the Copper Content of Certain Insects and Insect Products

Material	Percent Moisture	Mg cu per Kilo		
		Fresh	Dry	
ORTHOPTERA—				
<i>Periplaneta americana</i> , adults	(5)*	61 0	31 0	79 5
<i>Blattia orientalis</i> , adult males	(8)	70 6	24 2	85 7
<i>Blattia orientalis</i> , adult females	(19)	69 7	14 4	47 3
<i>Blattia orientalis</i> , adult females starved one week	(4)	67 6	6 1	18 8
<i>Blattia orientalis</i> , egg pouches	(1)	62 1	21 3	56 0
<i>Melanoplus femur-rubrum</i> , adults	(1)	68 8	21 6	69 3
COLEOPTERA—				
<i>Tribolium confusum</i> , pupa	(1)	59 8	25 9	64 5
<i>Bruchus obtectus</i> , adults	(5)	48 2	31 3	60 4
<i>Bruchus obtectus</i> , adults dead in culture	(2)	7 3	56 6	61 1
LEPIDOPTERA—				
<i>Ephestia kuehniella</i> , Larvae	(1)	62 1	18 8	52 4
<i>Samia cecropia</i> , pupa male	(5)	71 8	10 9	38 1
<i>Samia cecropia</i> , pupa female	(6)	73 1	9 7	35 8
<i>Samia cecropia</i> , inner cocoon	(1)	5 7	31 6	32 8
<i>Samia cecropia</i> , outer cocoon	(1)	6 1	38 0	40 5
DIPTERA—				
<i>Gastrophilus nasalis</i> , larvae	(1)	66 7	18 2	49 9
<i>Gastrophilus intestinalis</i> , larvae	(1)	64 7	13 5	38 4
<i>Cynomyia cadaverina</i> , larvae on whole egg	(1)	73 3	13 6	50 6
<i>Cynomyia cadaverina</i> , pupa on whole egg	(1)	71 9	21 0	74 7
<i>Cynomyia cadaverina</i> , larvae on beef	(1)	71 6	42 9	150 7
Blowfly, spp.? Larvae on chicken	(3)	70 7	19 9	68 7
Blowfly, spp.? Pupa on chicken	(1)	68 9	19 3	62 1

*These figures indicate number of tests

Since studies on the physiological role of copper in insects will be presented in a later report it will suffice here to say that copper is present in greater abundance in the cast skins of *Melanoplus femur-rubrum*, empty egg cases of *Blattia orientalis*, and inner cocoon of *Samia cecropia* than in the insects by which they are produced. On the other hand copper was present in detectable quantities in newly hatched *Blattia orientalis*.

It seems worth noting, also, that the copper content of certain insects (*Cynomyia cadaverina*) varies with the material upon which they are feeding and in certain insects (*Blatta orientalis*) is materially reduced by starvation.

Studies on the copper content of insect blood indicate that copper is less abundant in the blood than in certain tissues and waste products.

CONCLUSIONS.

I. Copper is accumulative in insects and is influenced to some extent by the diet.

II. Certain waste products are higher in copper, on a weight basis, than the insects by which they are produced.

III. Copper is present in measurable quantities in certain insect eggs, newly hatched nymphs, larvæ, pupæ, and adult insects.

IV. The blood of certain insects is lower in copper content than the tissues and waste products of the same insects.

LITERATURE CITED.

1. Callan, T. and Henderson, J. A. R. 1929. A new reagent for the colorimetric determination of minute amounts of copper. *Analyst* 54: 650-3.
2. Elvehjem, C. A. and Hart, E. B. 1929. Copper content of feeding stuffs. *J. Biol. Chem.* 82: 473-77.
3. Elvehjem, H., Steenback, H. and Hart, E. B. 1929. Distribution of copper in blood. *J. Biol. Chem.* 83: 21-5.
4. Elvehjem, C. A., Steenback, H. and Hart, E. B. 1929. Effect of diet on the copper content of milk. *J. Biol. Chem.* 83: 27-34.
5. Grendel, F. 1930. A micro determination of copper in blood. *Pharm. Weekblad.* 67: 1345-51. *Chem. Abs.* 25: March, 1931.
6. Lindow, C. A., Elvehjem, C. A. and Peterson, W. H. Copper content of plant and animal foods. *J. Biol. Chem.* 82: 465-471.
7. Muttkowski, R. A. 1921a. Copper; its occurrence and role in insects and other animals. *Trans. Amer. Microscopical Soc.*, 40, 144-157.
8. Muttkowski, R. A. 1921. Studies in the respiration of insects. I. The gases and respiratory proteins of insect blood. *Ann. Ent. Soc. Amer.*, 14, 150-156.
9. Rose, W. C. and Bodansky, M. 1920. Copper in marine organisms. *J. Biol. Chem.* 44: 99-112.
10. Supple, G. C. and Bellis, B. 1922. The copper content of cow's milk. *J. of Dairy Science* 5: 455-467.

off with dissecting scissors, and the outflowing, yellowish-green blood is caught in the dish. After the flow of blood has ceased, an incision is made just back of the head large enough to insert the tip of a 50 c.c. burette. The burette is filled with distilled water. Water is now slowly passed from the burette through the larva into the evaporating dish until the liquid flowing from the severed ends of the posterior prolegs is colorless. Usually 10 to 15 c.c. of water are sufficient. When this point is reached, the tips of the other 4 pairs of prolegs are snipped off to determine by the color of the liquid issuing from them whether the lower portion of the body cavity has been freed of blood. If the removal of the blood is incomplete more water is passed through the larva. The evaporating dish with its contents of diluted blood is placed in a drying oven at 85° to 90° C., and the contents are dried to constant weight. The figure thus obtained is the dry weight (total solids) of the blood of the larva. The blood volume may be obtained by dividing this value by the dry weight of 1 c.c. of blood. The latter figure is found by making a separate determination of the dry weight of a known volume of blood. In nine determinations each of 10 c.c. of blood taken from larvæ in the fifth instar the weight per c.c. varied from 0.0781 gm. to 0.1138 gm., the mean being 0.0896 gm. The value used to compute the blood volume in the 6 determinations given in Table I was 0.09 gm.

The larva of *Galleria mellonella* was handled in much the same manner but because of its smaller size greater care was necessary to insure complete removal of the blood. The total solids per c.c. of the blood varied in 8 determinations made on volumes of 0.02 c.c. to 0.1 c.c. from 0.0732 gm. to 0.1850 gm., the mean being 0.1242 gm. The value 0.12 gm. was used to calculate the blood volume. The instars of the larvæ used were not ascertained.

The agreement of the mean values obtained by the two methods for *Bombyx mori* is good and indicates that the blood volume in c.c. of the silkworm in the late instars is equal to about 30 per cent of the body weight. The blood volume of *Galleria mellonella* calculated in the same way is about 41 per cent of the body weight.

Nazari⁴ found that the weight of the blood of the silkworm was equal to about one-fifth of the weight of the larva. He

⁴Nazari, A. Atti della R. Accademia dei Georgofili. Firenze (IV ser.) Anno 25, vol. 80, pp. 356-363. 1902.

removed the blood by cutting off the posterior dorsal horn and by making incisions in the prolegs. On the basis of his determinations, the blood volume would be 18.1 per cent, a value considerably below any obtained in this study except when the removal of the blood was known to be incomplete. Landois⁶ found that the ratio of the weight of insect larvæ to the weight of the blood is 4:1, and cites the larva of the moth *Macrothylacia* (*Gastropacha*) *rubi* L. as an example in which this ratio has been observed. Assuming the specific gravity of the blood to lie between 1.01 and 1.04 the blood volume would be 24+ per cent. A simple bleeding method was apparently used, and complete removal of the blood was probably not attained. Bishop⁷ states that the blood of the honeybee larva (worker) comprises 25 to 30 per cent of the body weight. Presumably his figures refer to per cent of the blood by weight to the total body weight. Using his value of 1.045 for the specific gravity of the blood, the blood volume in c.c. would lie within the limits of 23.9 and 28.7 per cent of the total weight. The method of determining the weight is not given, but the agreement with the figures given above for the blood volume of the silkworm is good. Haber⁸ finds that the adult cockroach (*Blattella germanica* L.) contains about 68 per cent of body moisture of which he assumes one-third or about 20 per cent to be blood. He states that the moistness of the tissues is due to a serum which doubtless is derived from the blood plasma. For this reason it is difficult to learn the exact blood volume of an insect. The methods described above are at best only approximations of the true blood volume but as approximations they may be useful in several ways.

The quantity of water in the silkworm of the fifth instar has been shown by Kellner⁹ to be about 80 per cent by weight. Adopting 30 c.c. per 100 gm. of larvæ as the approximate blood volume, the per cent of the blood by weight will be about 31.2 of which 28.4 per cent is water, leaving 51.6 per cent by weight of water bound in the tissues.

The methods described herein have been tested only on immature insects. It is known that the blood volume of certain immature insects is larger than that of adult

⁶Landois, H. Zeitschr. f. wiss. Zool. vol. 14, pp. 55-70, 1864.

⁷Bishop, G. H. Jour. Biol. Chem. Vol. 58, pp. 543-555, 1922-24.

⁸Haber, V. R. Bull. Brooklyn Ent. Soc. vol. 21, No. 3, pp. 61-100. 1926.

⁹Kellner, O. Die landwirthschaftlichen Versuchs-Stationen, vol. 30, pp. 59-86. 1884.

individuals^{1,2}. Mature forms of many insects have elongated appendages and body structures which can probably be drained of blood only with great difficulty. For such insects one of the indicator methods which have been used on vertebrate animals might be adopted.

AN ERGATANDROUS FORM IN PONERA OPACICEPS MAYR.*

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This description is based on two specimens which were collected by the junior author on August 25, 1930, from a colony of *Ponera opaciceps* Mayr, beneath the bark of a pine tree at Landon, Mississippi. That the specimens are not callow workers, as first supposed by the junior author from a superficial examination of them in the field, is clearly indicated by their 13-segmented antennae, the general shape of their bodies, and the prominent genital appendages at the apex of their gasters.

Ponera opaciceps Mayr.

Ponera opaciceps Mayr, Verh. Zool.-bot. Ges. Wien, Vol. 37, p. 536 (1887), worker and female.

Ponera opaciceps M. R. Smith, Annals Ent. Soc. Amer., Vol. 22, p. 545 (1929), male.

Ergataner: (Plate I., Figures 2 and 3). Length of head .68-.76 mm; length of thorax .935-.965 mm.

Head, including mandibles, longer than broad; posterior border almost straight, and sides subparallel, thus giving the head a more rectangular appearance than with the worker. Mandibles moderately broad, triangular, edentate stubs. Clypeus strongly convex, protuberant. Antennae 13-segmented, gradually but not strongly enlarging distally; scapes short, subcylindrical, approximately equal in length to the second, third, and fourth segments of funiculi taken together. Compound eyes small, almost circular, separated from the base of the mandibles by a space equivalent to approximately one and one-half times their greatest diameter. Thorax short, robust; viewed laterally the pro-mesonotal and meso-epinotal sutures are very distinct, especially

*Contribution from the Mississippi Agricultural Experiment Station.

on the dorsum; mesonotum strongly gibbous, clearly projecting above the general surface of the pronotum and epinotum. Between the mesonotum and epinotum the suture is represented by a very strong constriction, following which the epinotum forms a rather long and gentle arch terminating at the petiole. The basal surface and declivity of the epinotum merge into each other so gradually that they are hardly distinguishable. Petiole large, robust, anterior and posterior faces convex, superior border rounded. Gaster similar to that of the worker, but bearing prominent genital appendages.

Color sordid yellow; margins of compound eyes and antennal cavities black, articulation of legs and sutures of thorax brown.

Ponera opaciceps Mayr is without doubt the most common species of *Ponera* in the southern part of Mississippi. Farther north in the state it is replaced by *Ponera trigona* var. *opacior* Forel and by *Ponera coarctata* subsp. *pennsylvanica* Buckley. In the Americas it ranges from Brazil and Uruguay to at least as far north as Texas and Mississippi. Although the worker and female were described by Mayr in 1887, and the ants have been taken on numerous occasions since, this is the first time that anyone has observed ergataners as far as we are aware. Ergataners have been found to occur in several other species of *Ponera*, namely: *P. eduardi* Forel, *P. punctatissima* Roger, and *P. ergatandria* Forel. It is therefore not surprising that *P. opaciceps* should have this peculiar worker male-like form. Of the species here mentioned, *P. ergatandria* was the only form in this country previously known to have ergataners.

The writers greatly regret that the two specimens on which this description is based are apparently immature as is evidenced by their extremely pale color, and by the fact that their body wall shrank considerably when the specimens were taken from alcohol and mounted. In shipping, the gaster of each was detached and lost, hence it is not figured here. The authors studied both gastres before they were lost, and are positive that each bore prominent male genitalia at their apex.

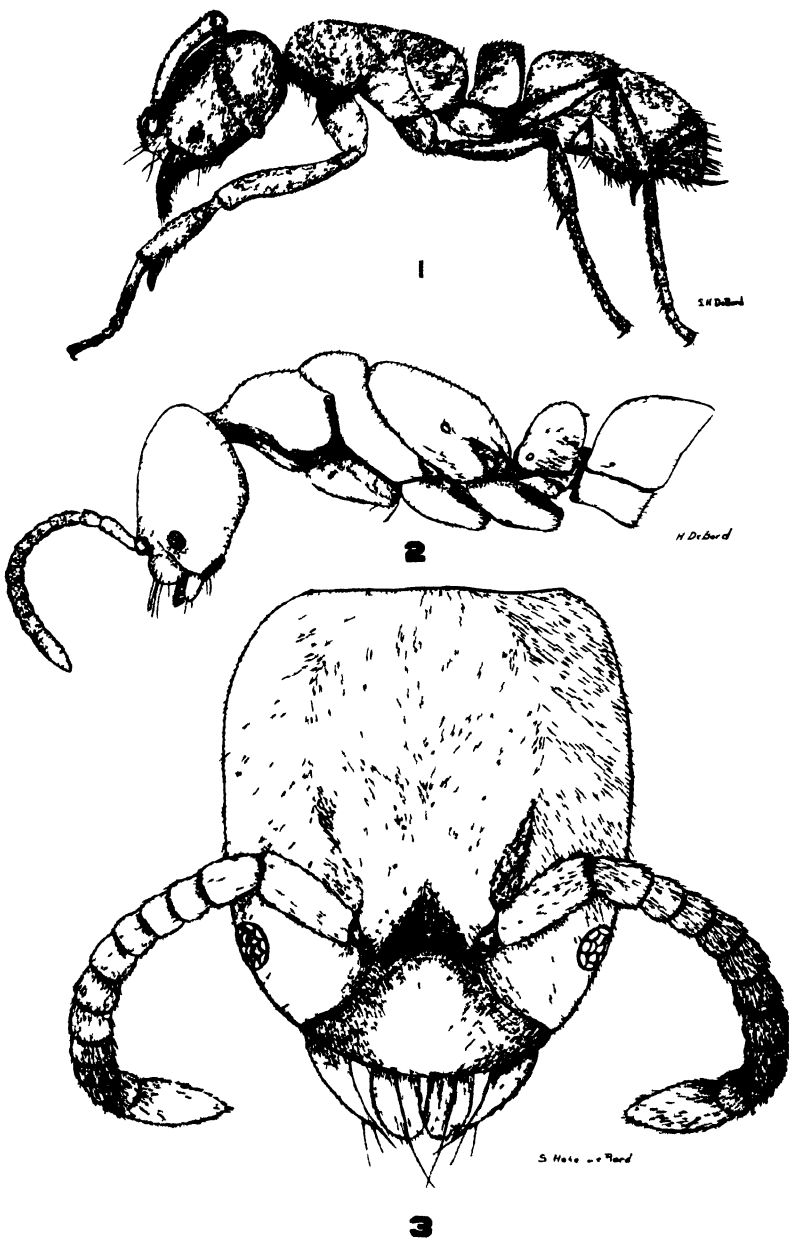
EXPLANATION OF PLATE.

Ponera opaciceps Mayr.

Fig. 1. Lateral view of worker.

Fig. 2. Lateral view of ergataner showing head, thorax, petiole and base of gaster.

Fig. 3. Front view of head of ergataner.



**THE CORNELL UNIVERSITY ENTOMOLOGICAL EXPE-
DITION TO SOUTH AMERICA, 1919 AND 1920,
SCIENTIFIC RESULTS, NUMBER 5,
HEMIPTERA-TINGITIDÆ.**

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Through the courtesy of Dr. J. Chester Bradley, the writer has been permitted to study the Tingitidæ collected by the Cornell Expedition in South America. This collection is represented by twenty-two species, four of which are described below as new. The types are deposited in the collection of Cornell University, Ithaca, New York. Unless otherwise noted under the species, the specimens were collected by Dr. Bradley.

***Monanthia monotropidia* Stål.**

Lassance, Minas Geraes, Brazil, 1 female.

***Monanthia parmata* Distant.**

Posadas Misiones, Argentina, January 16-24, 1920, 1 male and 3 females.

***Monanthia figurata* Drake.**

Lassance, Minas Geraes, Brazil, November 9-19, 1916, 1 female.

***Teleonemia sacchari* Fabricius.**

Belle Horizonte, Minas Geraes, Brazil, November 1-6, 1919, 1 male.

***Teleonemia proluxa* Stål.**

Diamantina, Minas Geraes, Brazil, November 14-18, 1919, 1 male; Lima, Peru, May 16, 1920, 1 female.

***Teleonemia scrupulosa* Stål.**

Aquicauana, Matta Grossa, Brazil, December 11-13, 1913, 1 male.

***Tigava pracellens* Stål.**

Bello Horizonte, Minas Geraes, Brazil, November 1-6, 1919, 1 male.

***Tingis americana* Drake.**

Lassance, Minas Geraes, Brazil, November 14, 1919, R. G. Harris, collector, 1 female.

***Acanthocheila kahavala* Kirkaldy.**

El Campamiento, Col. Perené, Peru, June, 1920, 1 female.

***Leptocysta sex-nebulosa* Stål.**

Aracataca, Magdalena, Colombia, August 2, 1920, 1 female.

***Leptobyrsa mendecina* Pennington.**

Pttrerillos, Mendocina, Argentina, altitude, 4,000 feet, March 16-20, 1920, 53 specimens.

***Leptobyrsa elegantula* Drake.**

Rio de Janeiro, October 30, 1919, a male; El Campamiento, Col. Perené, Peru, June 18, 1920, 1 male.

***Leptopharsa magnifica* Drake.**

Lassance, Minas Geraes, Brazil, November 9-19, 1919, 1 female.

***Leptodictya dohrni* Stål.**

Tambo Eneñas, Cam. del Pichis, Peru, July 4, 1920, 7 specimens.

***Leptodictya madelinæ* Drake.**

Tambo Eneñas, Cam. del Pichis, Peru, July 4, 1920, 13 specimens. The discoidal area is considerably broader in the female than in the male; the number of confused rows of areolae varying from four to six in the male and from six to nine in the female. The nervelets of the areolae (two at base and increasing to five or six at apex) along the outer margins of the costal area are dark fuscous, the marginal row of areolae being clouded with fuscous. The nervures of the distal half of the elytra are also very dark fuscous.

***Leptodictya grandatis*, n. sp.**

Differs from *madelinæ* in having five long sharp spines on the head, narrower and more widely reticulated costal area. Discoidal area narrower, with four to six areolae at its widest part. Costal area with one row of clouded areolae along outer margin, the nervelets along the margin and distal portion black-fuscous. In *madelinæ* the dark area along the outer

margin wider and, also, more of the nervelets along the outer margin and in the distal half of the elytra black-fuscous.

Head black, with five long slender black-tipped spines. Antennae long, slender, brownish black; segment I about two and a half times as long as two; III three times as long as four; I and II black. Rostrum extending to end of sulcus; rostral laminae strongly developed. Pronotum moderately swollen, coarsely pitted, tricarinate; lateral carinae parallel, foliaceous, each uniseriate; median carinae more strongly elevated, especially anteriorly, mostly uniseriate, biseriate in front. Paranota completely reflexed, resting on sides of pronotum, biseriate above and triseriate below. Hood moderately large, narrow, projecting over basal portion of head. Hood, paranota and carinae testaceous, the areolae translucent.

Elytra rather broad, testaceous, the nervures separating areas and along the outer margins, nervelets of subcostal, most of sutural, some of discoidal, and near outer margin and portion of costal area black-fuscous; areolae somewhat confused and slightly variable in size, except row along outer margin of costal area clouded with fuscous; subcostal area biseriate, vertical; discoidal area with an oblique, fuscous nervure; costal area broad, with three oblique, depressed, slightly enlarged nervures, the outer row of areolae partly or entirely clouded with fuscous, more coarsely reticulated along the subcostal area than in *madelina*. Male claspers long, strongly curved, very thick at the base.

Length, 4.85 mm.; width, 2.12 mm.

Tambo Eneñas, Cam. del Pichis, Peru, July 4, 1920, 5 specimens; *holotype*, male, (Cornell U., No. 1016.1) and *allotype*, female, (Cornell U., No. 1016.2). In *L. williamsi* Drake the hood is much more compressed and narrower, the spine blunt, and without clouded areolae along the outer margin of costal area.

***Gargaphia subpilosa* Berg.**

Potrerrillos, Mendocina, Argentina, March 16–20, 1920, altitude, 4,000 feet; many specimens; Tigre, Buenos Aires, February 8, 1920, 1 male; Urucum, Corumbá, Brazil, 1 male. A photograph of Berg's type enables the writer to determine this species.

***Gargaphia torresi* Costa Lima.**

Corumbá, Matta Grossa, December 14–23, 1919, and Lassance, Minas Geraes, Brazil, several specimens. This species feeds and breeds on cotton in Brazil. Its wild host plants are unknown.

***Dicysta braziliensis* Drake.**

Upper River, Pachitea, Peru, July 21, 1920, 1 female.

Leptobyrsa bradleyi, n. sp.

Moderately elongate, rather broad, testaceous, the reticulations with a few dark fuscous spots, the areolae hyaline. Head short, brown, with three very long slender testaceous spines, the anterior pair much shorter and curved inwardly. Rostrum reaching to the intermediate coxae; rostral laminae rather widely separated on metasternum, cordiform. Bucculae contiguous in front. Hood small, compressed, faintly produced in front. Paranota rather broad, somewhat rounded, strongly reflexed, mostly quadriseriate, the areolae hyaline and moderately large. Pronotum strongly narrowed anteriorly, somewhat embrowned, distinctly punctate, tricarinate, each composed of a single row of areolae; lateral carinae slightly constricted beyond the middle and, also, slightly converging behind.

Elytra widening posteriorly, their tips separated, costal area broad, the areolae rather large and slightly confused in arrangement, with four cells at its widest part; subcostal area moderately broad, with three rows of rather small areolae; discoidal long, narrow at both base and apex, widest behind the middle, considerably impressed, finely reticulated, with six or seven cells at its widest part, bounded by strongly raised veins. Margins of elytra clothed with long fine hairs; hairs on reticulations fine and rather sparse. Legs testaceous, the tarsi brown. Antennae testaceous, pilose, the apical segment almost entirely black. Body beneath pale brown. Wings clear, a little longer than the abdomen.

Length, 3.92 mm : width, 2.12 mm.

Holotype, male (Cornell U. No. 1017.1) and *allotype*, female (Cornell U. No. 1017.2). Matucana, Peru, May 27, 1930; 6 paratypes—two taken with type, two from Huacapistana, Rio Tarma, and two from Huacapistana, Rio Tarma, June 1-3, 1921, Peru. This tingitid is named in honor of Dr. J. Chester Bradley, who has taken a very keen and active interest in South American insects. The species is very distinct and not easily confused with other members of the genus.

Gargaphia opima, n. sp.

Moderately elongate, rather narrow, about the size of *G. lasciva* Gibson, but with a smaller hood, broader and differently marked costal area. Antennae long, slender, pilose; segment I rather long, two and a half times as long as two, dark brown to almost black; II short, slender, dark brown to black; III long, brown; IV long, brownish black. Rostrum reaching to the middle of the mesosternum. Body beneath blackish. Legs brown, the tarsi darker.

Pronotum black, tumid, finely pitted; hood small, faintly produced in front, compressed; paranota entirely biseriate, strongly reflexed, the outer margin rounded. Carinae foliaceous, uniseriate, brown, the areolae moderately large; lateral carinae parallel, extending as far

anteriorly as base of hood, but rather widely separated from it; median carina not more strongly raised. Elytra with nervures in apical portion, discoidal area, basal portion of subcostal area, two or three slightly enlarged oblique nervures in costal area and marginal nervure fuscous-black the areolae hyaline; costal area moderately broad, with four areolae at base and five at widest part, the areolae somewhat confused and moderately large; subcostal area biseriate; discoidal area rather short, widest beyond middle, rather closely reticulated, with five or six cells at its widest part; wings slightly longer than abdomen.

Length, 3.51 mm.; width, 1.38 mm.

Holotype, male (Cornell U. No. 1018.1) and *allotype*, female (Cornell U. No. 1018.2), Miriatiriani, Cam. del Pichis, Peru, July 9, 1920; 3 paratypes, taken with type.

***Gargaphia decoris*, n. sp.**

Elongate, broad, testaceous, the pronotum brown, the elytra with three to five transverse nervures in costal area (tending to form a transverse band) and an elongate spot on outer boundary of discoidal area dark fuscous. Head brownish, with five rather long slender spines. Rostrum extending almost to the transverse laminae. Antennae long, slender, pilose, brownish; the last segment (except basal portion) fuscous black; segment I stout, rather long, three times as long as two, the latter short and much more slender; III very long, two and a half times as long as four.

Pronotum considerably swollen, closely pitted, reticulate behind; hood small, strongly compressed, almost sub-truncate in front. Paracosta rather broad, strongly reflexed, almost erect, mostly triseriate, quadriseriate opposite humeri, rather widely reticulated. Elytra broad, broadly rounded behind, the tips not widely separated; costal area very broad, the areolae rather large, not regularly arranged in rows, and about six deep at widest part; discoidal area broader in female than male, closely reticulated, rather short, broadly rounded at apex, widest beyond the middle. Legs brownish, the tarsi dark fuscous. Areolae hyaline. Body beneath brownish black.

Length, 5.12 mm.; width, 2.66 mm.

Holotype, male (Cornell U. No. 1019.1) and *allotype*, female (Cornell U. No. 1019.2), Bello Horizonte, Minas Geraes, Brazil, November 1-5, 1916. Paratypes, 20 specimens, taken with type. Closely allied to *G. obliqua* Stål, but differing in the more strongly constricted lateral carinae, shorter discoidal area, and differently marked elytra. The carinae are considerably raised, uniseriate, rather thick; the transverse fascia of costal area formed by the black-fuscous nervures, the areolae being hyaline.

AN ADDITIONAL NOTE ON THE BEHAVIOR OF HIBERNATING POLISTES WASPS.

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A recent paper* tells how hibernating *Polistes* wasps, after spending the winter in shelter away from the nest, visit the home at intervals, whenever the temperature is favorable, and finally return in the spring to the old home site, and from there and not from their place of hibernation do they disseminate and found colonies of their own.

There is nothing in the paper, however, to show what their behavior is during the early part of the fall when they are first taking leave from the nest. A few fortunate observations this year reveal what happens in the lives of the wasps during this significant interval when their interest in nesting has ceased and their attention is turning gradually to their winter welfare.

My first inkling that fraternizing increases at the end of the season was gained on August 27, 1930†, when I noticed that an orphan‡ nest which normally had only three adults, suddenly at noon harbored twelve wasps, all workers or queens, which had come to the nest from unknown sources. Another nest near by (not an orphan one) had ten workers, its normal population, on this date.

Two weeks later, September 11, these 22 adults on both nests had dispersed, but ten wasps were huddled in a crack between two ceiling boards of the shed, four and eight feet distant from the two abandoned nests. This crack was four feet long, and there was ample space where the ten could have spread themselves out if they had so desired, but they were piled one atop the other in a compact mass, so that the bodies of some were hanging out in full view.

This observation shows for *P. pallipes*, as I have already shown for *P. annularis*, and *P. rubigenosis*, that gregariousness

*Rau, "The Behavior of Hibernating *Polistes* Wasps." Ann. Ent. Soc. Amer. 23: 461-466. 1930.

†The unusual drought caused dissemination earlier than usual that year.

‡Orphan nests are those nests in which the queens have been lost, or removed in an experiment, and the management of the nest, even to the laying of infertile eggs, devolves upon the orphan workers.

is a factor in their hibernation. The most interesting and perplexing point, from the standpoint of psychology, is the fact that, even though the temperature is still high enough for comfort, they prepare for hibernation.* But this location afforded only temporary shelter, and as the season advanced they dispersed to other quarters, as follows.

Two days later, September 13, they were still in the crack, but in the afternoon two of them broke away from the crowd and walked a few inches away, where they found another hiding-place further up in the same crack. The others had extricated themselves from the group and ranged in single file, with heads deep in the crack and tails protruding. The next day at 10:00 A. M., the two groups were in the same places and positions, excepting that two more wasps had deserted the large group, and behold! they had again taken up residence on the nest! As in *P. annularis*, these visits strengthen their memory of the old home, so that when they wake from their winter's sleep elsewhere, they return to it and found the new colonies near the site.

At 2 P. M., it became very dark, preceding a storm, when in my presence one of the two left the nest and joined the company in the crack. The remaining one declined to follow the crowd; she asserted her independence by persistently clinging to the old, empty nest, and on September 16 she was still there, huddling behind the comb. That night it rained and the temperature fell; the following day I found the group crouching deeper in the crack, and whereas previously they had rested in single file with the abdomens protruding to the wind, they now had pulled in their tails after them and assumed their old position, one atop the other, to get in out of the cold and conserve body warmth.

On September 15, there was a drop in temperature after the rain, and with that it became apparent that this crack was probably only a temporary hibernating spot, because the next morning three had disappeared. Another cold night followed, with a minimum of 60° F., followed by a warmer afternoon when the mercury rose for a while to 85°. I came home that evening expecting to find that they had sought more secure quarters, for I knew that they would not be able to survive the

*This habit of clustering and remaining immovable on the chilly days was noticed among wasps seen at large and also those kept in cages.

winter in that poor protection. True to my expectations, they had gone; the exodus had taken place some time during the day, when the temperature was higher. In other words, a period of generally cooler weather had aroused in the wasps an inclination to come together, even from different nests, and seek to satisfy their immediate needs for protection in some place near the nest. But a nip of real cold had convinced them that they must escape to safe quarters before cold should benumb them and preclude activity; in this case they had availed themselves of the warm afternoon following the night of 60°. This combination of temperatures supplied ideal conditions for the beginning of true hibernation; the 60° would convince the wasps of the need of seeking shelter, and the higher temperature for a few hours, while the chill was fresh in their minds, would give them the opportunity to move before too late. I think that we should be able to find out experimentally the various optimums of temperature for each stage in the hibernating period.

These few observations show mainly that the wasps do not, as by a date on the calendar, dig themselves in for the winter, but gradually, with misgivings and frequent displays of behavioristic adaptations, they adjust their activities to the new conditions. In this prolonged exile, which is a large event in the lives of these queens (they probably are queens), memory of the home region is, as I said before, a large factor in the selection of a site for the founding of the new colony.

With the prehibernating behavior of *P. pallipes* in mind, I can now appreciate the observation of the prehibernation of *P. annularis* on September 12, 1930, as observed at Old Mines, Missouri. Here a nest of *P. annularis* was attached to a post near a stream. A thorough search in the vicinity revealed only this one nest. The cells were all empty, but about twenty adult females (presumably queens) still clung to it. They were idle and listless; it seemed to me that they were ready to disperse and hibernate, if indeed some of the colony had not already done so. A search nearby under bark and stones revealed none. Fortune favored me, however, for in two knot-holes or cavities in two fence posts nearby I discovered groups of wasps which, I supposed, had come from this nest. One hole harbored fifteen wasps, the other ten, huddled in these inadequate shelters. The afternoon warmth was inviting, and

the wasps of both lots were ready to fly in the sunshine when I attempted to take them. Some of them, when disturbed, spat out enormous drops of glistening water. Both posts were less than twenty feet from the nest, and in the light of my observations on *P. pallipes* I can only assume that these wasps had come from this nest, and had taken up temporary hibernation nearby before making the choice of final quarters. These *P. annularis* again showed gregariousness, and it appears, since there were no other nests in the vicinity, that the sisters keep together over the winter. It is possible, also, that when I discovered the twenty on the nest, they were only in the act of revisiting their former home from their temporary abode.

On September 14, at Allenton, Missouri, I found in two empty wren-houses ten and twelve *P. annularis*, apparently seeking this type of shelter. Their nests were not in the bird houses but they came to them in mid-afternoon, when the sunshine was warm.

BIBLIOGRAPHY.

At the request of the Editor, I herewith append a complete list of my papers on Polistes Wasps.

1918. Experiments on the homing of *Polistes pallipes*, and biological and behavior data on four species of *Polistes* wasps; pp. 244-295, *Wasp Studies* Afield, Princeton Univ. Press. (Jointly with N. L. Rau.)
1928. Honey gathering habits of *Polistes* wasps. *Biol. Bull.* 54: 503-519. Modification of nest building habits in *Polistes*, *Psyche* 35: 147-150. Trophallaxis in *Polistes pallipes*, *Psyche* 35: 153-156. The reconstruction of destroyed nests by *Polistes* wasps, *Psyche* 35: 151-152. Autumn and spring in the life of the Queen *P. annularis* and *P. pallipes*. *Bull. Brooklyn Entom. Soc.* 23: 230-235.
1929. The silk spun by the larvae of certain social wasps, *Canad. Entom.* 61: 219-221. At the end of the season with *Polistes rubiginosis*, *Ent. News* 40: 7-13. Orphan nests of *Polistes*, *Ent. News* 40: 226-232, 256-259. Coloration in *Polistes pallipes*, *Psyche* 36: 34-36. Habits and dissemination of four species of *Polistes* wasps, *Ecology* 10: 191-200.
1930. Ecological and behavior notes on *Polistes pallipes*, *Canad. Entom.* 62: 143-147. Mortality of *Polistes annularis* during hibernation, *Canad. Entom.* 62: 81-83. Life history notes on *Polistes annularis*, *Canad. Entom.* 62: 119-120. Animosity and tolerance in several species of *Polistes* wasps, *Journ. Comp. Psychol.* 10: 287-296. Behavior of hibernating *Polistes* wasps, *Ann. Ent. Soc. Amer.* 23: 461-466.
1931. *Polistes* wasps and their use of water. (To appear in *Ecology*.) The nesting habits of *Polistes rubiginosis* with special reference to pleometrosis. (To appear in *Psyche*.) The nests and nesting sites of four species of *Polistes* wasps. To appear in *Bull. Brooklyn Ent. Soc.*

ON THE ANATOMY OF GRYLLOBLATTA CAMPODEIFORMIS WALKER.

1. Exoskeleton and Musculature of the Head.

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This is the first of a series of papers on the anatomy of the primitive Orthopteran *Grylloblatta campodeiformis* Walk., which it is hoped may be ready for publication from time to time within the next few years. The present contribution deals with *Grylloblatta* only, comparisons with other Orthopteroid insects being reserved for the next paper of the series.

The observations recorded were made almost exclusively from dissections of adult specimens preserved in 70% alcohol and potash preparations. Serial sections were made from three specimens but were of little assistance in the study of either chitinous structures or musculature. As the material was limited unusual care was taken in the dissections. All the muscles recorded were observed at least twice.

EXOSKELETON OF THE HEAD.

The Head Capsule. In general form and position the head of *Grylloblatta* is very like that of an earwig (e.g., *Forficula* or *Anisolabis*), being flattened and prognathous and usually held almost horizontally. The positions of the antennæ and compound eyes are also similar to those of the Dermaptera. The surface is smooth, with a clothing of short setæ, which are for the most part scanty but are abundant on the antennæ and palpi. Those of the antennæ are fine, short and uniform, those of the palpi longer and less uniform in length.

The head capsule (Pl. I, 1-3), exclusive of the clypeus, is about as broad as long, well rounded behind and laterally and truncated in front. The *antennal sockets* (Figs. 1, 3-5, *as*) are situated immediately behind the mandibular articulation and laterad of the epistomal suture. Each socket is subcircular, with an antero-internal angle, and is surrounded by a thickened and somewhat elevated rim, which bears a small ventral projection or *antennifer* (Figs. 3, 4, *af*), upon which the antenna is pivoted.

The *compound eyes* (Figs. 1-5) are somewhat smaller than the antennal sockets, situated laterally at a distance of about their own longitudinal diameter from the base of the mandible and about half that distance from the outer rim of the antennal socket. They are

black-pigmented and composed of about sixty rounded facets, separate from one another and arranged in slightly irregular rows. Around each eye is a slightly thickened rim, best developed antero-dorsally, where the heavier cuticle is continuous with that of the rim of the antennal socket.

The *epistomal* (fronto-clypeal) *suture* (Figs. 1, 4, *es*) is distinct and marks the position of a broad, low, internal ridge (Figs. 2, 5), which is continuous on each side with the anterior arm of the tentorium and the dorsal articulation of the mandible.

The *anterior tentorial pits* (Fig. 4, *ap*) are continuous with the epistomal suture at the antero-ventral edge of the rim of the antennal socket.

The *clypeus* (Fig. 1, *cl*) is large, rounded in front, and distinctly divided into a proximal, well-sclerotized postclypeus, and a distal, more membranous and somewhat larger anteclypeus. As seen in potash preparations these parts are clearly marked but not separated externally by a suture.

At the base of the clypeus, on each side, is the *dorsal articulation of the mandible* (Fig. 3, *dm*), a ginglymus joint consisting of (1) a small rounded convexity just in front of the antennal socket, and (2) mesad of this, a small concavity at the basal angle of the clypeus. Both of these parts are more heavily sclerotized than the neighbouring cuticular areas. Extending from the ventro-lateral margin of the antennal socket, downwards and forwards, and around to the ventral surface, terminating at the ventral articulation of the mandible, is the *subgenal suture* (Figs. 1, 3, 4, *sg*), which separates from the gena the so-called "trochantine of the mandible." It marks the position of a strong internal ridge (Fig. 5, *sg*), which joins the postero-ventral margin of the anterior arm of the tentorium.

From the dorsal portion of the ocular rim a well-marked suture (Figs. 1, 3, *ps*) and internal ridge extends backwards and slightly inwards to the postero-lateral angle of the occipital foramen. These ridges form a pair of arches which give strength to the otherwise somewhat thinly sclerotized head capsule, connecting, as they do, the firm areas at the base of the mandibles and about the eyes and base of the antennæ with the thickened rim of the occipital foramen, the tentorium forming the brace which connects these parts ventrally. These sutures, which may be called the *parietal sutures*, divide the dorsal and lateral regions of the head capsule, behind the eyes, into median and lateral areas.

In the median area can be seen the primitive *epicranial suture* (Fig. 1, *ec*), which is distinct in the adult insect, although less conspicuous than in the earlier stages. It is indicated by lines of thinner cuticle than elsewhere, there being no corresponding internal ridges. The stem of the suture (*coronal suture* of Snodgrass), extends from the occipital foramen to a point a little behind the eyes. The *frontal sutures*, or arms of the epicranial suture, diverge widely, terminating near the hind margins of the antennal sockets, where they are met by the dorsal arms of the tentorium.

The lateral areas of the epicranium are continued forward below the eyes to the subgenal sutures and include the gena. They are bounded ventrally by the *occipital sutures* (Fig. 2, *oc.*), which are well marked but incomplete posteriorly, extending from the mandibular articulation, where they are continuous with the subgenal suture, to a point about opposite the middle of the occipital foramen.

The *gena*, as defined by Snodgrass, is the "parietal area behind and below the eyes." This definition is based upon insects with vertically placed mouth-parts, such as a typical locust. As applied to a prognathous insect like *Grylloblatta*, the words "behind and below" must be changed to *below and before*. According to this definition the gena of *Grylloblatta* is a very small area, being merely that part of the lateral surface of the head which lies in front of the eyes and behind the subgenal suture.

The ventral and postero-ventral region of the head capsule, nearly surrounding the occipital foramen, is the occipital region. It is not defined dorsally, where it is continuous with the parietal areas, but it is bounded laterally by the occipital sutures.

The *postoccipital suture* (Fig. 2, *poc*) is distinct but the postoccipital rim is extremely narrow. Antero-ventrally the sutures curve out below to terminate in the *posterior tentorial pits* (Fig. 2, *pp*). These are narrow, oblique, flattened pits, somewhat elongated posteriorly in common with the general elongation of parts in this region.

The *occipital foramen* is large, elongate quadrangular, narrowing evenly from the hind margin forward. Anteriorly it occupies a horizontal plane but posteriorly it is curved dorsad, so as to face postero-ventrad. On each side of the foramen, about midway of its length is a small condyle (Fig. 2, *cv*) for the articulation of the lateral cervical sclerites.

The main part of the *occipital region*, comprising *occiput* and *postgena* is not definitely divided into these areas. In contrast to the gena and in correlation with the forward position of the mouth-parts, the postgena, or that part of it in front of the occipital foramen, is elongated, so that the articulation of the mandibles lies far anterior to that of the maxillæ.

The ventral articulation of the mandible (Figs. 2, 5, *vm*) consists of a small socket at the anterior end of the postgena, bounded above by the projecting end of the subgenal ridge. Into this socket fits the mandibular condyle.

At the point of articulation of the cardo of the maxillæ there is a slight prominence (Fig. 2, *mxc*) of the ventral margin of the head capsule at the outer extremity of its junction with the posterior arms of the tentorium.

The tentorium is very like that of *Forficula*. The body (Fig. 2, *t*), which includes the frontal plate ("laminatentorium" of McGillivray), is relatively narrow and flat in its posterior half, except where it curves downward behind at its junction with the posterior arms. Anteriorly it is expanded and dorsally concave where it meets the anterior and dorsal arms. The *anterior arms* (Figs. 2, 4, 5, 23, 27, *at*) are triangular,

with the base arising just below the antennary sockets and the somewhat twisted apices converging to join the body of the tentorium. The inner or anterior side is continuous with the epistomal ridge and the outer or posterior side with the subgenal ridge. The *dorsal arms* (Figs. 2, 26, 28, *dl*) arise from the dorso-lateral edges of the body of the tentorium, just behind the anterior arms. They are broadest at base but taper as they pass upward, so that they are very slender near their tips but are suddenly expanded just before they join the roof of the head capsule at the outer ends of the frontal sutures. The *posterior arms* (Fig. 2, *pl*) are short, broadly triangular and strongly divergent, so that their anterior margins are transverse. They pass downward and outward to the basal articulation of the maxillæ. On the ventro-anterior margin of each arm, just mesad of the articulation of the maxilla, is a small tubercle for the attachment of the median retractor muscle of the labium (Fig. 2, *lt*).

APPENDAGES OF THE HEAD.

The *antennæ* (Figs. 20, 21) are a little longer than the head and first two thoracic segments together and are composed of 28 or 29 segments. The first segment or scape is much the largest. It is somewhat less than twice as long as its middle diameter, subcylindrical but slightly constricted in the middle, and largest near the distal end. It swings upon a pivot formed by the antennifer, a small ventral projection from the rim of the antennal socket (Figs. 3, 4, *af*). The second segment or pedicel is half as long as the scape and a little longer than broad. The scape and pedicel bear only a few bristles but the remaining segments, forming the flagellum, are fairly densely and uniformly covered with short hairs which become gradually finer on the distal segments. The segments of the flagellum are cylindrical, most of them somewhat enlarged distally and rounded at apex. They are of fairly equal diameter in the proximal half or less of the antenna, but distally they diminish in thickness and the constrictions between the segments become much more marked, in consequence of which the terminal segments break off readily.

The *labrum* (Fig. 1, *lr*) is a rounded flap, about as broad as long, constricted at its base, where it joins the clypeus. Its upper surface is moderately sclerotized, the dark brown spot on each lateral margin not being specially hardened. Slender hairs of moderate length are thinly and rather evenly distributed over the surface. The lower or epipharyngeal surface (Fig. 2) is membranous except at the outer or basal corners, where there is a small sclerite, the *lorma* (Fig. 2, *lm*), bearing a dorsal tubercle, and from which two small bars pass backwards and inwards in the epipharyngeal wall of the clypeal region. The epipharyngeal surface of the labrum bears two longitudinal groups of very short setæ, parallel with the lateral margins. The epipharyngeal surface of the clypeus seems to be devoid of hairs.

The *hypopharynx* (Figs. 6, 7, 8, 16, 28, 29, *hy*) is a broadly oval, somewhat flattened lobe, slightly narrowed toward the base. The

broader distal portion is flexible but bears no hairy, membranous, sensory area, such as usually occurs in orthopteroid insects. Its cuticle is thinly sclerotized, more firmly so along the lateral margins, where a pair of ill-defined lateral bars may be distinguished. The narrower proximal part of the hypopharynx is supported ventrally by a V-shaped sclerite (Fig. 7, *hw*), the apex of which lies in the labiohypopharyngeal angle and bears the small, crescentic opening of the salivary duct (Fig. 7, *sd*), no salivary cup being present. The arms of the V-shaped sclerite are distally expanded and are continuous, at the lateral margins, with the suspensorial bars (Figs. 6, 8, *hs*). These are a pair of broadly triangular plates, whose apices meet in the middle line, at about the proximal third, to form a narrow bridge, completing with the ventral sclerite a girdle for the support of the base of the hypopharynx. Each suspensorial bar bears at its basal angle two branches, an *oral* and a *mandibular*. The oral branch (Figs. 6, 8, 29, 30, *hso*) is a more or less upright, slender bar on each side of the mouth opening and connected with the pharyngeal wall, on which it is somewhat expanded. The mandibular branch (Figs. 6, 8, 29, 30, *hsm*) is much thicker and strongly curved. It lies more horizontally, just below the mouth opening, and its distal end comes into close relation with the inner basal angle of the mandible.

The *mandibles* (Figs. 9-16) are large and heavily sclerotized, especially at the apices and along the mesal margins, where they are deeply pigmented. They are slightly convex above and concave below, the apices curving inward and slightly downward. Each mandible has a proximal tooth a little before the middle of the inner margin, and a pair of distal teeth, the larger of which is apical, the smaller subapical. Except where interrupted by the proximal tooth the inner margin has a cutting edge along its entire length, the proximal and distal parts of which meet at a broadly obtuse angle. There is no indication of a molar surface.

The subapical tooth of the right mandible (Fig. 11) is entirely marginal but that of the left (Fig. 12) is continued a short distance on the ventral surface in the form of an oblique ridge. Between the ridge and the apical tooth there is a slight furrow into which the apical tooth of the right mandible appears to fit when the jaws are closed. The proximal tooth of the right mandible is single and but slightly notched, while that of the left mandible is distinctly notched and there is another smaller tooth just behind it, the notch between the two possibly serving as a socket for the reception of the proximal tooth of the right mandible when the jaws are closed.

The dorsal articular surface (Fig. 9, *dm¹*), like the corresponding surface of the head capsule (Fig. 3, 5, *dm*) is concavo-convex, the concavity being laterad of the convexity, which is a small but prominent process fitting into the hollow at the outer basal angle of the clypeus. The ventral condyle (Fig. 11, *mc*) is a prominent rounded knob a little nearer the outer margin than is the dorsal articulation.

The mandibles bear a few moderate-sized setae on the convex surface and a very few much smaller ones on the concave surface.

The *maxillæ* (Figs. 17, 18) are large, projecting slightly beyond the tips of the mandibles, and typically orthopteroid in structure.

The *cardo* (*cd*) and *stipes* (*st*) show the usual division into lateral and mesial areas due to the presence of a strong internal ridge (*str*), which gives support to the parts concerned and to some extent serves for muscular attachment. The suture dividing the *cardo* (*cdv*) is curved and subparallel to the mesial margin. It reaches the lateral margin just distal to the *basal arm* (*cda*), to which the abductor muscle is attached. The basal arm is well developed and projects inward over a slight concavity in the margin of the head capsule. Just mesad of the arm the *cardo* bears a very minute marginal prominence representing the articular condyle. It fits against the edge of the head capsule, which is slightly raised at this point. The *cardo* is bounded laterally by a distinct ridge connected below with the basal arm.

The ridge of the *stipes* divides the latter rather near the mesial margin, as in the Orthoptera, the outer part being broad and extending well over to the dorsal surface. There is no indication of a palpifer.

The terminal lobes are rather slender and strongly curved, very like those of an earwig in form, and their tips are practically coincident. The proximal segment of the *galea* (subgalea, *sgl*) is short and does not appear distinctly in ventral view, but is seen in a lateral or dorsal view. It terminates distally in a marked dorsal prominence, which is readily seen in profile. The distal segment of the *galea* (*g*) is strongly arcuate, flat and falciform, with a small rounded apex. On its concave edge near the apex is a slight convexity (Fig. 34), separated from the apex by a slight notch. This convexity bears numerous small hairs, which are doubtless sensory.

The *lacinia* (*l*) is curved similarly to the *galea* and is well sclerotized and deeply pigmented. Its inner margin is concave throughout its entire length, except at base where it bears a prominent tooth. There is also a small ante-apical tooth some distance before the sharp apex. Along the concave edge, between the two teeth, is a row of about fifteen fairly stiff bristles.

The *maxillary palpi* (*mxp*) are of moderate length, the segments rather densely hairy especially the last three. The first segment is short, the second very little longer, the third twice as long as the second, the fourth equal to the third, and the fifth a little longer. Each segment is gradually enlarged distally.

The *labium* (Fig. 19) is elongate with a large submental region divided into two distinct and free sclerites, the primary and secondary submental plates¹.

The *primary submental plate* (*sm*¹) is slightly broader than long, widest nearer the base, the front and hind margin straight and the lateral margins convexly curved, the postero-lateral angles rounded off. It is rather strongly arched longitudinally and bears scattered, rather coarse, setæ, chiefly near the lateral margins.

¹These are the sclerites usually known as submentum and mentum respectively.

The *secondary submental plate* (*sm*²) is a little more than half as wide as the primary plate and nearly half as long as broad. It bears a few scattered setæ.

The conjunctiva between submentum and prementum is unusually well developed and is partly exposed, this exposed part bearing a small median sclerotized area.

The *mentum*² (*m*) is cleft half way to its base, the remaining part being divided by a deep median groove which marks the position of the labial apodeme. This is a strong internal ridge which curves from the base of the mentum forwards and upwards between the bases of the glossæ to the base of the hypopharynx, where it becomes continuous with the apex of the V-shaped sclerite of the latter. No sutures are present to mark off the palpifers from the more mesial region of the mentum.

The *paraglossæ* (*pg*) are separated from the mentum by a faint suture distinct only in dorsal or lateral view. They are not divided into two segments. They are slender, sub-cylindrical, slightly incurved, somewhat emarginate mesially towards the apices, which are bluntly rounded and densely covered with fine sensillæ. Their ventral surfaces and mesial margins are thinly clothed with ordinary setæ, of which one, near the apex, is longer than the others.*

The *glossæ* (*gl*) are separated ventrally from the mentum by a fine suture. They lie in the same plane as the paraglossæ and are a little shorter than the latter. They are flat, elongate-triangular, with straight sides, slightly emarginate mesially before the apices, which are bluntly pointed and beset with fine sensillæ.

The *labial palpi* (*lp*) are about as long as the primary submental plate, the first two segments subequal in length, the third about a third longer than the second, each a little enlarged distally. The first segment has only a few coarse setæ, the second a few coarse ones mixed with shorter, finer hairs, the third thickly covered with the finer type of hairs, a few of which are larger than the others.

MUSCLES OF THE HEAD.

The Labrum (Figs. 26-29).

1. *Levators of the labrum*.—A pair of contiguous muscles forming a flat median bundle of parallel fibres arising from the middle of the frons just in front of the frontal sutures and inserted on the base of the dorsal wall of the labrum. (The *anterior retractors* of Snodgrass.) These muscles, judged by the movements of living insects, act both as levators and retractors.

2. *Depressors of the labrum*.—Two muscles arising from the frons a little anterior and lateral to the origin of the levators, the fibres running parallel and passing forwards and slightly outwards to be inserted on a small dorsal process of the tormæ at the base of the ventral wall of the labrum. (The *posterior retractors* of Snodgrass.) These muscles appear to act both as depressors and retractors of the labrum.

*This is the sclerite usually called prementum and also known as the stipulae and the labiostipites.

The Stomodaeum (Figs. 26-29).

3. *Dorsal dilators of the buccal cavity*.—A pair of flat muscles arising from the base of the dorsal wall of the labrum laterad of the insertion of its levator muscles and passing backward and inward to be inserted on the roof of the buccal cavity.

4. *Retractors of the mouth angles*.—A pair of stout bundles of somewhat converging muscle fibres arising from the frons close to the origin of the depressors of the labrum, passing downward, forward and slightly inward to be inserted on the upper part of the oral branch of the hypopharyngeal suspensorial bars.

5. *Protractors of the mouth angles*.—A pair of very slender muscles arising from the epistomal ridge just mesad of the antennal fossæ and passing downward, backward and inward to be inserted on the posterior margin of the oral branch of the hypopharyngeal suspensorial bar.

6. *First dorsal dilators of the pharynx*.—A pair of very slender muscles arising from the frons close to the base of the clypeus and about midway between its lateral margin and the median line, and passing downward, inward and backward to their insertion on the roof of the pharynx just laterad of the frontal ganglion.

7. *Second dorsal dilators of the pharynx*.—A pair of somewhat larger muscles arising from the frons close to the origin of the depressors of the labrum and just behind a line drawn through the hind margin of the antennal sockets, the fibres passing downward and slightly inward to their insertion on the roof of the pharynx near the middle line, on each side of the posterior part of the frontal ganglion.

8. *Third dorsal dilators of the pharynx*.—A pair of long slender muscles arising from the parietal areas near the middle line and about half way between bases of antennæ and occiput. They pass downward and forward, spreading out fanwise, and are inserted on the roof of the pharynx behind the bases of the anterior arms of the tentorium.

9. *Lateral dilators of the pharynx*.—A pair of short fan-shaped muscles with somewhat divergent fibres, which arise from the medio-dorsal surface of the base of the dorsal arms of the tentorium and, passing inward and slightly downward, are inserted on the lateral wall of the pharynx.

10. *First ventral dilators of the pharynx*.—A group of short fibres arising from the anterior part of the dorsal surface of the body of the tentorium, continuous with the origin of the lateral dilators, and inserted on the ventral wall of the pharynx. With the lateral dilators they form a continuous band of fibres across the ventral half of the pharynx in this region.

11. *Second ventral dilators of the pharynx*.—A very slender group of fibres arising on each side from the posterior arms of the tentorium close to the occipital foramen and passing forward to their insertion in the ventral wall of the pharynx opposite the insertion of the third dorsal dilators of the pharynx.

The Antennæ (Figs. 22-26).

12. *Levator of the antenna*.—A fairly stout bundle of slightly convergent fibres, arising from the upper part of the dorsal arm of the

tentorium and passing forward and slightly outward, to be inserted by a short tendon on the medio-dorsal part of the base of the first antennal segment.

13. *Inner depressor of the antenna*.—A flat muscle arising by a very broad base from the ventro-lateral surface of the anterior and dorsal arms of the tentorium and the included angle. Passing forward and outward the fibres converge to their insertion on the ventro-lateral part of the base of the antennæ.

14. *Outer depressor of the antenna*.—A flat fan-shaped muscle arising from the ventro-lateral surface of the dorsal arm and adjacent part of the body of the tentorium, below the depressor, the fibres passing outward and forward to a tendon which is inserted in the postero-lateral part of the base of the antennæ.

15. *Extensor of the flagellum*.—A stout bundle within the scape, arising dorsally from its base just beyond the insertion of the levator muscle and inserted dorsally on the basal margin of the pedicel.

16. *Flexor of the flagellum*.—A somewhat smaller muscle arising ventrally from the base of the scape just beyond the pivot on which the antenna turns, and inserted ventrally on the basal margin of the pedicel.

The Mandibles (Figs. 26, 28, 31, 32).

17. *Abductor of the mandible*.—A slender muscle arising from the dorso-lateral region of the head capsule as far back as the occipital region, the fibres laterad of the tergal adductor (18), converging forward to their insertion into the lateral part of the base of the mandible, which is somewhat emarginate at this point. The greater part of the muscle lies directly behind the eye.

18. *Tergal adductor of the mandible*.—A large, powerful muscle, arising from the dorso-lateral, lateral and occipital regions of the head capsule, the fibres in two main heads, a larger one from the dorsal, lateral and postero-lateral regions, subdivided into two or three smaller groups, and a smaller head arising from the postero-dorsal region. Both bundles consist of numerous converging fibres, which are inserted on a strong tendon attached to the inner angle of the base of the mandible. The tendon is stout and subcylindrical at base but spreads out behind into a broad, thin lamina, to which the muscle fibres are attached.

19. *Tentorial adductor of the mandible*.—A very short, fairly thick muscle arising from the dorsal surface of the anterior arm of the tentorium and passing forward and upward to be inserted on the dorsal wall of the mandible within its cavity and near the base.

20. *Hypopharyngeal adductor of the mandible*³.—A very small muscle arising within the cavity of the mandible from the dorso-lateral surface, at about the proximal third, the fibres passing backward and inward to an extremely fine tendon which is inserted on the mandibular branch of the suspensorial bar of the hypopharynx.⁴

³This muscle, as shown by Snodgrass ('28) is morphologically a vestigial ventral adductor of the mandible, but, if it functions at all, it probably moves the hypopharynx rather than the mandible (v. Mangan '08).

⁴The exact point of insertion of this muscle has not been observed.

The Maxillæ (Figs. 33-34).

21. *Abductor of the maxilla*.—A somewhat conical muscle, broadest at its origin on the postero-ventro-lateral region of the head capsule, including parts of the parietal and occipital areas. The fibres converge as they pass forward to their insertion on the end of the basal arm of the cardo.

This muscle, in *Dissosteira*, is regarded as a promotor by Snodgrass ('28), but in *Grylloblatta* it seems to have the function of an abductor, and as such it has been considered by most authors.

22. *Adductor of the maxilla*.—A broad, flat muscle arising from the lateral margin of the body of the tentorium along its entire length, the fibres converging as they pass outward to their insertion on the cardo. Most of the fibres are inserted laterad of the ridge and close to the articulation with the stipes, but a small group is inserted mesad of the ridge. In the specimen figured a few fibres were inserted on the stipital side of the articulation.

23. *Flexor of the stipes*.—A broad, thick muscle, lying beneath the adductor of the maxilla, arising from the whole length of the body of the tentorium near its lateral margin and from the anterior surface of the posterior arm of the tentorium, the fibres converging slightly as they pass outward and slightly forward to their insertion on the mesial area of the stipes and the stipital ridge.

24. *Cranial flexor of the lacinia*.—A long, slender muscle with parallel fibres arising from the occipital region of the head capsule, passing forward and downward beneath the adductor of the mandible and above the tentorial muscles of the maxilla to its insertion on the inner side of the base of the lacinia.

25, 26. *Stipital flexors of the lacinia*.—There are two of these, a stout dorsal muscle and a much smaller ventral one. The dorsal muscle (25) arises from the outer wall of the stipes, passes obliquely across the stipes, with slightly converging fibres, to its insertion on the base of the lacinia immediately laterad and distad of the insertion of the cranial flexor. The ventral muscle (26) arises from the basal half of the ventro-lateral wall of the stipes, passing forwards and slightly inwards to its insertion on the outer part of the base of the lacinia, ventral to the insertion of the dorsal muscle. These two muscles are represented in *Blatta* and *Dissosteira* by a single digastric muscle.

27. *Flexor of the galea*.—A flat bundle arising by two or three heads from the outer wall of the stipes between the two stipital flexors and passing forward beneath the palpal muscles to its insertion on the inner side of the base of the galea.

28. *Extensor of the maxillary palpus*.—A slender bundle arising from the ventral wall of the stipes distal to the origin of the ventral stipital flexor and passing outward and forward to its insertion on the posterior edge of the base of the first palpal segment.

29. *Flexor of the maxillary palpus*.—A bundle of similar size to the preceding, arising from the ventral wall of the stipes, just distad of the origin of the extensor of the palpus, and following a similar course to the latter to its insertion on the anterior edge of the base of the first palpal segment.

30, 31, 32, 33. *Muscles of the maxillary palpus*.⁵—A single muscle for each segment, viz., an extensor of the second segment and a levator of the third segment, both arising in the basal part of the first; a flexor of the fourth segment arising from the posterior wall of the third; and a flexor of the fifth segment arising from the anterior wall of the fourth.

Labium and Hypopharynx.⁶ (Figs. 30, 35).

34. *Lateral retractors of the labium*.—A pair of stout bundles of parallel fibres, becoming distally compressed, each arising from a tubercle on the ventral margin of the posterior arm of the tentorium and passing forward to a broad insertion on the lateral basal margin of the palpiger (sides of mentum).

35. *Median retractors of the labium*.—A pair of contiguous muscles with parallel fibres, arising from the middle region of the primary submental plate and passing forward to a broad insertion on the basal margin of the mentum.

The distal retractors of the labium, usually found in orthopteroid insects, are wholly absent in *Grylloblatta*.

36. *Dorsal dilators of the salivary orifice*.—A pair of short muscles arising from the suspensorial bars of the hypopharynx and converging downward to a common insertion on the base of the ventral wall of the hypopharynx, immediately above the aperture of the salivary duct (*sd*).

37. *Ventral dilators of the salivary orifice*.—A similar pair of muscles arising from the sides of the palpiger, immediately distal to the insertion of the lateral retractors of the labium, and converging upward to their insertion on the median labial apodeme immediately below the aperture of the salivary duct.

These two pairs of muscles apparently act not only as dilators of the aperture of the salivary duct but also as compressors of the salivary reservoir by approximating the upper wall of the hypopharynx and the lower wall of the labium.

38. *Protractors of the hypopharynx*.—A pair of small bundles each arising from the ventral wall of the mentum, near the base of the palpus, and converging upward to their insertion on the fold between the hypopharynx and labium, on each side of the aperture of the salivary duct.

According to Snodgrass this muscle, in *Dissosteira*, is inserted on the sides of the salivary cup, but in *Grylloblatta* there is no such cup, the salivary duct opening by a simple orifice from which the insertions of the muscles are quite distinct.

The *retractors of the hypopharynx*, generally present in orthopteroid insects and the largest muscles attached to the hypopharynx, are wholly absent in *Grylloblatta*.

⁵These muscles are named here in accordance with the movements of the segments in relation to the longitudinal axis of the appendage, rather than to that of the insect as a whole, as Snodgrass has done in the case of *Dissosteira*. Unless this method is followed there seems to be no possibility of achieving uniformity in the terminology of homologous muscles in different insects, since the position of the head and consequently of the mouth-parts varies greatly in relation to the longitudinal axis of the body.

⁶See also No. 20.

39. *Flexor of the paraglossa*.—A flat bundle arising from the outer half of the base of the labiostipes and inserted into the inner part of the base of the paraglossa.

40. *Flexor of the glossa*.—A somewhat smaller bundle arising from the inner half of the base of the labiostipes and inserted into the inner part of the base of the glossa.

41. *Abductor of the labial palpus*.—A very small bundle of short fibres, arising from the lateral wall of the palpiger and inserted on the ventro-lateral part of the basal margin of the first palpal segment.

42. *Adductor of the labial palpus*.—A much larger muscle than the last, arising from the distal end of the labial apodeme between the bases of the glossæ and passing outward to its insertion on the anterior side of the basal margin of the first palpal segment.

43, 44. *Muscles of the palpal segments*.—Two muscles, an extensor of the second segment (43), arising from the posterior side of the base of the first segment and inserted on the posterior side of the base of the second segment, and a flexor of the third segment (44) arising on the anterior side of the base of the first segment and inserted on the anterior side of the base of the third segment.

REFERENCES.

For a full bibliography on the insect head capsule, see Snodgrass ('28). The following list comprises the references which were of special importance in the preparation of the present paper.

- Basch, S. (1865). Untersuchungen über das Skelet und die Muskeln des Kopfes von *Termes flavipes*. *Zeit. Wiss. Zool.*, **15**: 56-75, pl. 5.
- Berlese, A. (1909). *Gli Insetti*, I. Milan.
- Borner, C. (1909). Neue Homologien zwischen Crustaceen und Hexapoden. Die Beissmandibeln der Insekten und ihre phylogenetische Bedeutung. *Zool. Anz.*, **34**: 100-125, 9 figs.
- Comstock, J. H. and Kochi, C. (1902). The skeleton of the head of insects. *Amer. Nat.*, **36**: 13-45, 29 figs.
- Crampton, G. C. (1915). The thoracic sclerites and systematic position of *Grylloblatta campodeiformis* Walker, a remarkable annectant "orthopteroid" insect. *Ent. News* **26**: 337-350, pl. 13.
- Crampton, G. C. 1917a. A comparison of the antennae of the Grylloblattidae and Embiidæ to demonstrate the relationships of these two groups of insects. *Can. Ent.* **49**, 213-217.
- Crampton, G. C. 1917b. A phylogenetic study of the lateral head, neck and prothoracic regions in some Apterygota and lower Pterygota. *Ent. News*, **28**, 398-412.
- Crampton, G. C. (1925). The external anatomy of the head and abdomen of the roach *Periplaneta americana*. *Psyche* **32**: 135-220, pls. 5-7.
- Crampton, G. C. (1928). The eulabium, mentum, submentum and gular regions of insects. *Journ. Ent. and Zool.* **21**: 1-15, 3 pls.
- Crampton, G. C. (1926). The affinities of *Grylloblatta* indicated by a study of the head and its appendages. *Psyche* **33**: 78-84, figs. 1-4.
- DuPorte, E. M. (1920). The muscular system of *Gryllus assimilis* Fabr. *Ann. Ent. Soc. America* **13**: 16-52, pls. 1-7.
- Eidmann, H. (1925). Vergleichend-anatomische Studien über die Pharynx-musculatur der Insekten. *Zool. Anz.* **62**: 49-64, 5 figs.
- Hoke, Gladys (1924). The anatomy of the head and mouthparts of Plecoptera. *Journ. Morph.* **38**: 347-373, 6 pls.
- MacGillivray, A. D. (1923). *External insect anatomy*. Urbana, Ill.

- Mangan, J.** (1908). On the mouth-parts of some Blattidae. *Proc. R. Irish Acad.* 27, B: 1-10, pls 1-3.
- Snodgrass, R. E.** (1928). Morphology and evolution of the insect head and its appendages. *Smiths. Misc. Coll.* 81: No. 3, 158 pp., 57 figs.
- Stickney, F. S.** (1923). The head-capsule of Coleoptera. *Illinois Biological Monographs* 8, No. 1, 51 pp., 26 pls.
- Walker, E. M.** (1931). On the clypeus and labium of primitive insects. *Can. Ent.* 63: 75-81, pl. 6.
- Wu, C. F.** (1923). Morphology, anatomy and ethology of *Nemoura*. *Bull. Lloyd Library*, No. 23, *Ent. Series* 3, 81 pp., 16 pls.
- Yuasa, H.** (1920). The anatomy of the head and mouth-parts of Orthoptera and Euplexoptera. *Journ. Morph.* 33: 251-290, 9 pls.

ABBREVIATIONS.

- | | |
|--|--|
| ab—Tendon of mandibular abductor. | li—Labium. |
| ad—Tendon of mandibular adductor. | lp—Labial palpus. |
| af—Antennifer. | lr—Labrum. |
| an—Antenna. | lt—Tubercle for attachment of median retractor muscle of labium. |
| ap—Anterior tentorial pits. | m—Mentum. |
| as—Antennal socket. | mc—Mandibular condyle. |
| at—Anterior arm of tentorium. | md—Mandible. |
| cd—Cardo. | mx—Maxilla. |
| cda—Basal arm of cardo. | mxo—Maxillary condyle. |
| cdr—Cardinal suture or ridge. | mxc—Maxillary palpus. |
| c—Cerebral ganglion. | mxp—Maxillary palpus. |
| cl—Clypeus. | o—Mouth opening. |
| cv—Occipital condyle. | oc—Occipital suture. |
| dm—Dorsal mandibular articulation. | oe—Oesophagus. |
| dm'—Dorsal articular surface of mandible. | pg—Paraglossa. |
| dt—Dorsal arm of tentorium. | poc—Postoccipital suture. |
| ec—Epicranial suture. | pp—Posterior tentorial pits. |
| es—Epistomal suture. | ps—Parietal suture. |
| fg—Frontal ganglion. | pt—Posterior arms of tentorium. |
| g—Galea. | sd—Opening of salivary duct. |
| gl—Glossa. | sg—Subgenal suture. |
| hs—suspensorial apparatus of hypopharynx. | sgl—Subgalea. |
| hsm—Mandibular branch of same. | sm ¹ —Primary submental plate. |
| hso—Oral branch of same. | sm ² —Secondary submental plate. |
| hv—Ventral V-shaped sclerite of hypopharynx. | sog—Suboesophageal ganglion. |
| hy—Hypopharynx. | st—Stipes. |
| l—lacinia. | str—Stipital suture or ridge. |
| | t—Body of tentorium. |
| | tm—Torma. |
| | vm—Ventral articulation of mandible. |

EXPLANATION OF PLATES.

(All Figures are from preparations of *Grylloblatta campodeiformis* Walk.)

PLATE I.

- Fig. 1. Head capsule, dorsal view.
- Fig. 2. Same, ventral view.
- Fig. 3. Same, left lateral view.
- Fig. 4. Area including left eye and antennal socket, dorso-lateral view.
- Fig. 5. Area including right eye and antennal socket, from below and within.
- Fig. 6. Hypopharynx, dorsal view.
- Fig. 7. Hypopharynx, ventral view, with labium attached.
- Fig. 8. Anterior view of mouth-opening and surrounding parts, showing relations of the suspensorial apparatus of the hypopharynx to the mouth opening and mandibles.
- Fig. 9. Left mandible, dorsal view.
- Fig. 10. Right mandible, dorsal view.
- Fig. 11. Right mandible, ventral view.
- Fig. 12. Left mandible, ventral view.
- Fig. 13. Right mandible, mesial view.
- Fig. 14. Left mandible, mesial view.
- Fig. 15. Right mandible, base from below.
- Fig. 16. Head from beneath, with labium and left maxilla removed. Except the oesophagus, main tracheae, and muscles from tentorium to right maxilla, only the skeletal parts are shown.

PLATE II.

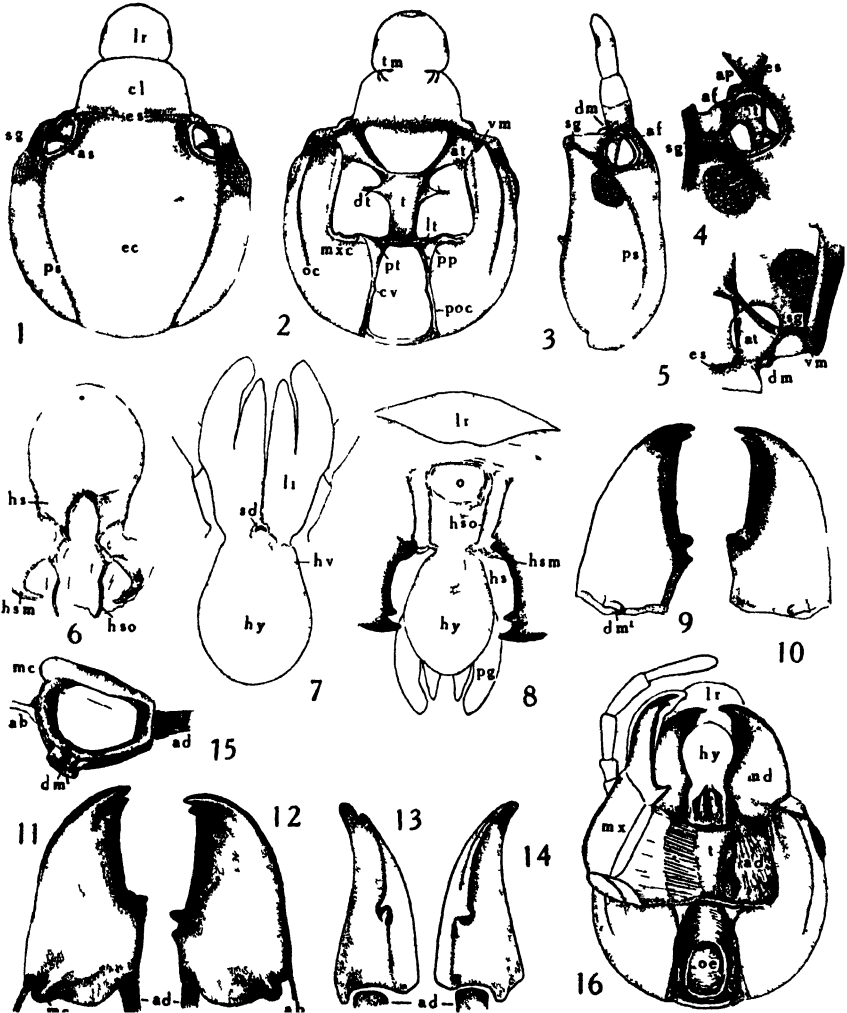
- Fig. 17. Left maxilla, ventral view.
- Fig. 18. Same, dorsal view of potash preparation.
- Fig. 19. Labium, ventral view.
- Fig. 20. Proximal segments of antenna.
- Fig. 21. Distal segments of antenna.
- Fig. 22. Basal muscles of antenna, right side, dorsal view.
- Fig. 23. Same, left side, dorso-lateral view.
- Fig. 24. Same, left side, ventral view.
- Fig. 25. Base of antenna, semi-diagrammatic, showing insertions of muscles.

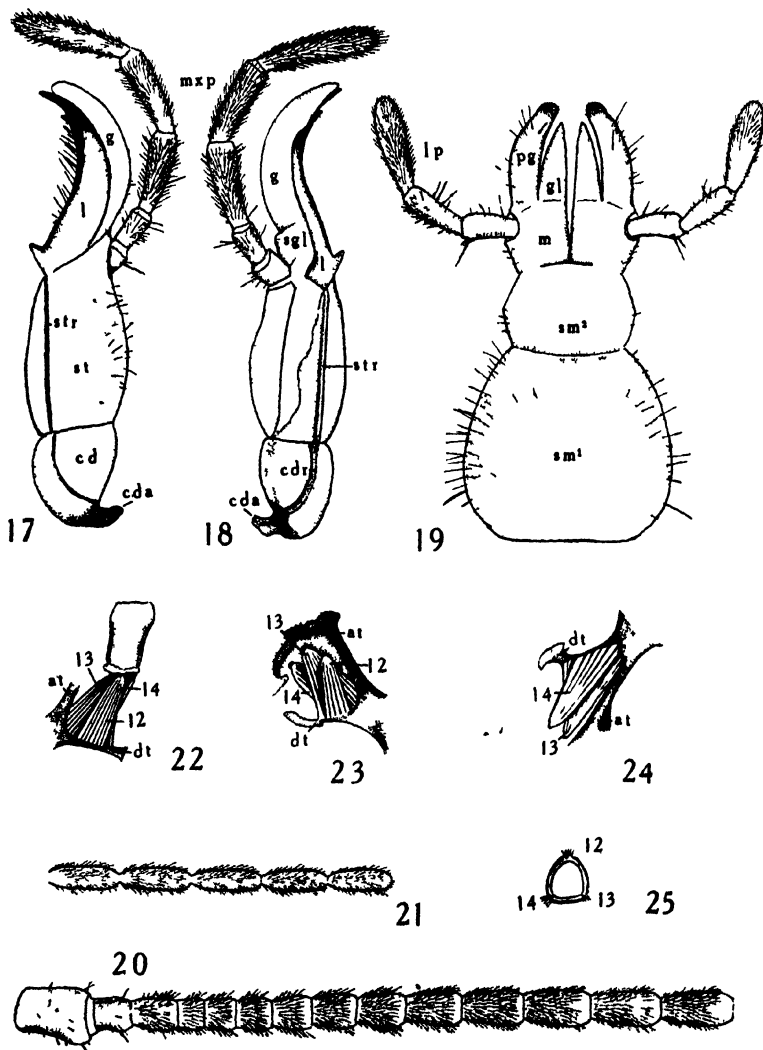
PLATE III.

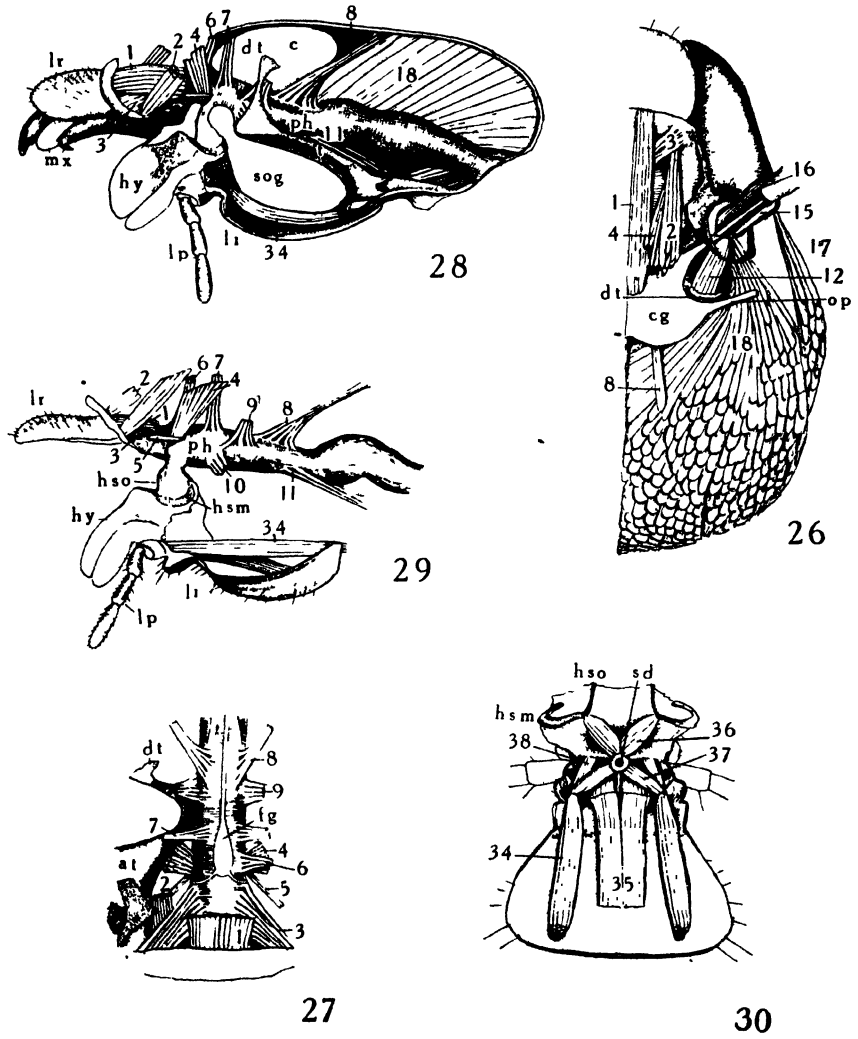
- Fig. 26. Dissection of head, right side, dorsal view, muscles in situ.
- Fig. 27. Dorsal view of pharynx, showing insertions of muscles.
- Fig. 28. Dissection of head, left side, showing positions of stomodaeal and hypopharyngeal muscles.
- Fig. 29. Left view of pharynx with labrum, hypopharynx and labium, attached, showing connections of these parts and associated muscles.
- Fig. 30. Muscles of labium and hypopharynx from within (postero-dorsal view of labium, postero-ventral view of hypopharynx).

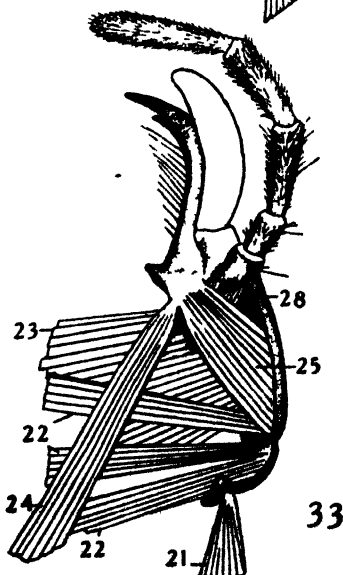
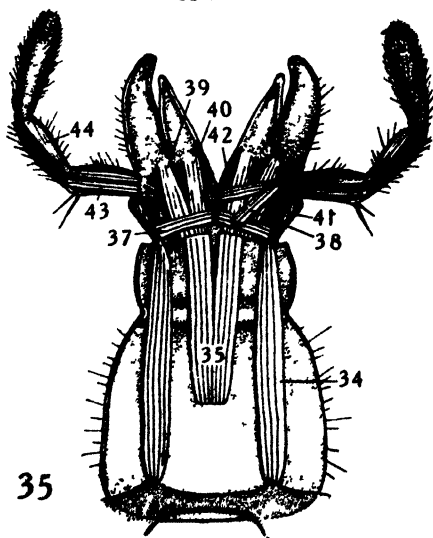
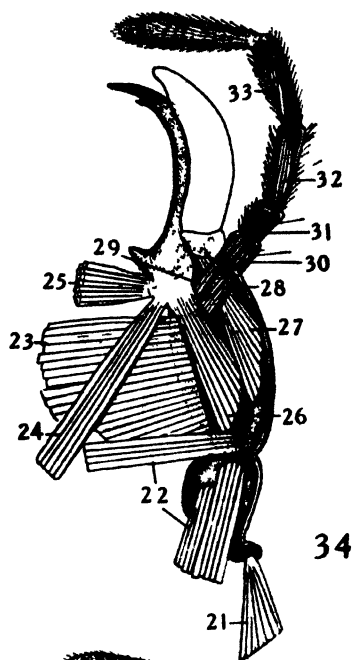
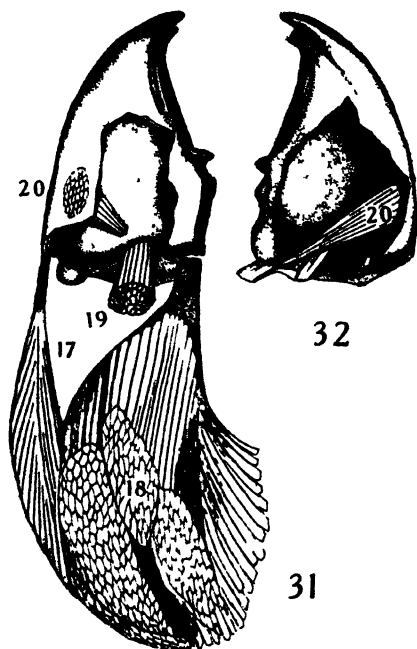
PLATE IV.

- Fig. 31. Left mandible with part of dorsal wall removed, showing muscles.
- Fig. 32. Same, with part of ventral wall removed, showing hypopharyngeal adductor within.
- Fig. 33. Right maxilla, dorsal dissection of muscles.
- Fig. 34. Same, with cardo extended and muscle 25 cut and turned over to show underlying muscles (26, 27, 29).
- Fig. 35. Labium, dorsal dissection of muscles.









SYMPHYLA FROM NORTH AMERICA.

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For the past few years I have collected specimens of this group where it was possible. To the northward I have searched in Canada and into Alaska and as yet not a single specimen from the more northern regions has come to me. Also in the northwestern United States I have as yet very few. Some specimens were collected in the eastern states, in California, in Lower California, in and near Mexico City and in Cuba. Many other places were searched without specimens. I have looked for them in many western National parks without success. This does not mean that they do not occur in these places, it merely means in some cases at least that the most favorable conditions of moisture and vegetation were not encountered in many of the places where a careful search was made.

Two works particularly have given me a basis for determination and classification, the extensive and comparatively recent paper of Hansen (1), 1904, and the brief but valuable paper of Bagnall (2), 1913. The many other papers referred to in the study were less useful and need not be discussed at this time.

Under the Subfamily Scutigerellinæ as defined by Hansen and Bagnall I have studied the following species:

Subfamily Scutigerellinæ

Scutigerella immaculata Newport. These were collected from a number of places in California, from Cuba, from New York State, and from Mexico.

Pseudoscutigerella americana n. sp. This type of a new genus may later be shown to belong to a distinct subfamily. I have representatives all of which seem to be the same species, from New York State, and from several situations in California. The type material was from Evey canyon near Claremont, California.

Hansinella californica n. sp. Specimens were collected in Southern California about fifty miles southwest of Claremont at Glen Ivy.

Subfamily **Scolopendrellinæ** Bagnall.

Scolopendrellopsis sensiferis n. sp. These were collected from Live Oak Canyon near Claremont.

Scolopendrellina californica n. sp. The new species and the type for the genus came from South Hills near Pomona, California.

Symphylella isabellæ Grassi. Specimens agreeing quite closely with this European species were found in a number of places in Southern California, near Redlands, near Claremont, near San Dimas. Some were found at Laguna Beach, some at Catalina Island, and Santa Cruz Island. They were also found in several places in Lower California.

Symphylella vulgaris Hansen. Specimens which seem to be this species were found near Claremont, near Pomona, near Corona and several other places in Southern California.

Symphylella santa n. sp. These were found on Santa Cruz Island.

Symphylella brevipes Hansen These were collected in the higher mountains of Southern California, a number of other places in Southern California, near Mexico City and in Cuba.

Symphylella cubæ n. sp. These were collected near Artesia, Cuba.

Scutigrella immaculata Newport.

I have collected specimens of this widely distributed species in a number of places. As there are some variations some indication of these will be given in the list.

Laguna Beach. A hundred or more specimens were collected near cultivated plants.

The longest were 5.8 mm., the head was about .4 mm. long and a little less wide.

The joints of the antennæ were variable but usually about 25 in number.

The first segment was .19 mm. long and .304 mm. wide. The second segment was .247 mm. long by .399 mm. wide.

The cerci were .342 mm. long by .038 mm. wide with the terminal spine .038 mm. long.

The basal appendages of the legs were in some cases more lobe-like than elongate, but this did not seem to be true for all. The first pair of legs in the first specimen mentioned were .319 mm. in length and the second pair were .418 mm. long. The last pair of legs was .446 mm. long.

In other features this and other specimens collected at the same place do not differ materially from other described members of this species.

Specimens from a small canyon near Lake Elsinore. Length, .5 mm. Head length, .266 mm. The ocellus is .023 by .021 mm. The first pair of legs is .152 mm. in length. The other legs are about .456 mm. in length. There are 17 joints in the antenna.

Specimens from Glen Ivy near Lake Elsinore, California. Total length, .95 mm. Length of the first leg, .076 mm. Length of the second leg, .104 mm. The last leg is .123 mm. The cerci are .204 mm. Sense papillæ are evident at the tip of the antenna and the head triangle has three short hairs. There are no other distinctive features.

Waverly, New York From the "Glen." The total length is 2.5 mm. There are eighteen joints in the antennæ. There seem to be few hairs on the dorsum, the eye spot is wider than long. This specimen is like others except that some are immature.

Mexico Valley. Specimens from two places do not differ from usual descriptions of this species. Specimens were obtained from situations about twenty miles distant from each other, some were among cultivated plants and others in wild land.

In some the head rod was shorter and with lateral branches not present.

Cuba. About twenty miles south of Havana in wild land. One of the specimens was of the following measurements: Total length, 2 mm. The head was .16 mm. long by .137 mm. wide. The first leg is .133 mm. long, the other legs .247 mm. long. The head rod is straight with slight lateral branches. There are two hairs in the head triangle.

***Pseudoscutigerella* n genus**

No scutæ marked, the whole body intricately folded and lobed with few short hairs. The segments are broadly rounded at their outer edges but form almost a straight line from side to side.

The head is slightly broader than long. The central bar not heavy with delicate lateral branches at right angles well forward and delicate branches at the caudal end. The head has few small hairs except a fringe at the cephalic margin. The head is not much wider than the general neck region. The head and body finely granular.

The legs have a fine pubescence but few long hairs. Internal supporting rods are evident connecting each pair. The first pair of legs well developed. The two terminal claws are prominent and equal.

The cerci are without stripes on the terminal area. The terminal hair is evident. The sense calicles near the base of the cerci are of the usual type.

The exopods are almost if not entirely lacking. Some low mounds in certain places suggest them.

***Pseudoscutigerella americana* n. sp.**

(Fig. 1, a, b.)

Length, 1.5 mm.

Head.—Length, .085 mm.; breadth, .1105 mm. The head rod is delicate, slender with a delicate cross line well forward and three small branches at its caudal extremity. The hairs on the dorsal surface are few and small, about eight in the type, but the front margin of the head has ten rather stronger ones at the front margin and others deeper. The ocelli are about .0148 mm. in diameter.

The Antennæ—17 joints, few hairs.

Body.—The divisions are well marked but with no indication of special plates. A few dorsal hairs are found on each segment. There are about 26 transverse foldings of the body or several for some segments, sometimes as many as three. On each side dorsally the hairs are about as follows: the first segment, 3; the second 4, with one medial; the third segment, 5; the fourth, 4. The next to the last segment has two on each side and two medial. The last segment has three lateral and two medial.

Legs.—The first leg is .09525 mm. long, with the joints of the following lengths beginning with the longest 5-(4,3,2)-1. The hairs on the first leg are: 3 on last joint, 1 on next to last, 2 on 3, 1 on 2. The second leg is .11475 mm. long and the joints are as follows: 5-3-4-2-1. Near the base of this is a rosette of ridges about an opening and near is a low fleshy lobe with no hairs. An internal rod runs between the pair of legs. There are four prominent hairs on the ventral side of the last joint. The third leg is similar to the last but three prominent hairs are near the tip of the fifth joint. The spiracular opening is surrounded by a rosette of ridges. The thick more or less median pair of low mounds like in the last has four short hairs. The 4th leg is similar but with no spines on the median pair of elevations between the legs.

The spiracular opening if it is such near the seventh pair of legs is elliptical with ridges running from it and surrounded by two rows of dots on each side. Opposite the 12th leg the spiracular opening is about one half as broad as the others with a whorl of ridges about. There are pairs of openings such as described opposite and between each pair of legs except the 9th, 10th, and 11th. The 12th leg is .119 mm. long. The joints are as follows beginning with the longest: 5-2-3-4-1. The hairs on the joints are as follows: 5, 3 hairs; 4, 2; 3, 1; 2, 2.

Cerci.—Length, .1147 mm., of which the terminal hair is about half in each case. The cirrus is about one-third the total length. There are nearly five rather regular whorls of short stiff hairs on the base

with indications between them of about four cross lines suggesting scales. The sense calicles near bear the usual long hair and have one other short hair near the rim of the large one. Near the calicle, between it and the cercus on each side is a spine with a basal joint as long as it is, the spine and its base being just a little shorter than the cercus.

The type and several specimens were collected in Evey Canyon near Claremont, California, November, 1929. Another bottle of specimens from Laguna Beach seems to be the same species. Other specimens from Ellis Creek, Waverly, N. Y., and the Glen, Waverly, N. Y., seem to be the same species. Minor variations in dorsal setæ and in some of the proportions are not enough to separate them from each other or from the California specimens from 2 localities.

***Hanseniella californica* n. sp.**

(Figs. 2a, 2b, 2c, 2d, 2e.)

Length, 2.5 mm.

Head.—Length, .19 mm. by .26 mm. wide. The head rod is rather thick, its center branching into a wide angle forward and dividing into a narrow angle caudally. There is no head triangle. The head has quite a number of hairs dorsally, on each side two or three cephalic lateral hairs are twice the length of most of the others. Between the antennæ are two long hairs.

Antennæ.—17 joints in the type. The basal joints have rather irregularly disposed long hairs, the hairs being considerably longer than the joints. The tip joints have rather longer hairs than usually found here with a tendency for two imperfect whorls. The hairs here are not as long as the joints. There was little indication of other special sense organs on the antennæ in addition to the rather stiff hairs.

Scuta.—The first scutum is .238 mm. wide by .0935 mm. long. There is forward pointing seta on the cephalic lateral region on each side. This hair is .0425 mm. long. On each side pointing backwards are two hairs longer than the rest or about .034 mm. long, while the other prominent hairs are at the longest about $\frac{3}{4}$ of this length. The second scutum is .30 mm. wide and .112 mm. long. On the lateral margin on each side is a large hair directed somewhat forwards. These are .036 mm. long. In addition there are two long hairs directed caudally. The third and all the remaining scuta but the last have two or three especially long hairs directed backwards and a considerable number directed forward. On the last and the lower segments although there are many stout hairs the differences between them are not so marked as towards the head.

Legs.—The first legs are .28 mm. long and .0425 mm. wide at the widest. In length the joints are as follows beginning with the longest: 5-2-3-1-4. The claws are equal, the tarsus has two long dorsal hairs. The tibia has a group of four strong hairs at its tip and on the dorsal side. The first joint has at least one long hair and the second joint of the leg four strong ventral hairs. There is a strong hair on the dorsal side of the third leg joint.

The last as well as the other legs are somewhat similar. In the last leg is .34 mm. long and .068 mm. wide at its widest. The first joint has one strong hair, the second one on its ventral side, the third joint two dorsal hairs, the third joint has five strong dorsal hairs, the last joint has two strong dorsal hairs. The joints of the last leg are as follows beginning with the longest: 5-4-2-3-1. The claws on the first and last legs are even in length but some of the more centrally placed legs have uneven claws. In addition to the numerous long hairs on all legs all joints have many very fine hairs covering them.

Basal appendages of the legs were noted; they were about .0425 mm. long by .0085 mm. wide with the spine .01275 mm. long as part of the total length.

Cerci.—These were .206 mm. long by about .05 mm. broad at their base. They are conical and clothed in about four imperfect whorls of long hairs. The terminal hair is about half as long as the cirrus.

Terminal Sense Hair.—The mound bearing this long hair is well marked, at the base are nine or more stiff spines in two nearly equal groups.

Locality.—Specimens were collected in Glen Ivy with at least two other species. The type is in the Pomona College collection. Another specimen from Evey Canyon some 50 miles distant seemed to be the same.

Distinctive Characters.—The distribution of the setae on the scuta, the spines on the legs are the distinctive features.

Scolopendrellopsis Bagnall.

Scolopendrella, Gervais.

The first pair of legs is well developed but not more than one half as long as the second pair. The cerci have several transverse lines across their distal parts. The central rod of the head is without lateral branches. The scuta are sharp pointed but without any striped belt.

Scolopendrellopsis sensiferis n. sp.

(Figs. 3a, b, c.)

Length, 1.67 mm.

Head.—Length, .133 mm.; width, .114 mm. The head rod is without lateral branches except at the extreme caudal end where there are two short lateral and one central portion. The rod seems divided or jointed about at its middle. The triangular area back of the head is almost lacking. The hairs on the dorsal part of the head are short and not numerous. There are four quite prominent ones between the antennæ. In addition to this there are eight short hairs on the central dorsal surface on each side and six more caudo-lateral also on each side. The mandibles have a number of prominent teeth.

Antenna.—In the type there are 17 joints. The two basal joints have almost no hairs and beyond this there is a single whorl of rather

short hairs. In every case these are much shorter than the segments to which they are attached. The last joint has a few short sense knobs and about six short hairs near its top. The next five joints in addition to short but not numerous hairs each have one or more prominent circular pits. In the type the next to the last terminal joint has the most, the next two joints back about the same and the next two progressively less.

Scuta.—The width of the first body segment is .114 mm., its length is .027. The total width of the second segment is .119 mm., its total length is .0425. The length of the points is .0425. The distance between the points is .0765. The third segment is .0765 mm. long and .136 mm. wide with the scuta .0765 mm. wide. Between the points the distance is .0425 mm. The length of the spines is .051 mm. The next to the last dorsal division is .034 mm. long and .136 mm. wide. The dorsal plate is .101 mm. wide. The points are .0425 long and .0574 mm. between them.

The last division from above is .1275 mm. long.

The first segment above has three hairs on a side, the outer being twice the length of the inner four. The second segment has six hairs in the more cephalic row, four in a central row, three on each spine and one in between. The third segment and some others are similar to this last. The next to the last segment has two rows of five hairs, then three on each spine and two between them. The last dorsal division has beginning with the cephalic region rows of hairs as follows: 4 6-3-3-2-3-4.

Legs.—The first leg is .05 mm. long. The joints beginning with the longest are: 3-5 4-1 2. The basal leg rods are separate and point cephalad. The second legs are .1 mm. long with the joint lengths as follows: 5.4.2.3.1. The leg rods are arched and connected from side to side in this and many other legs. The last leg is .0935 mm. long; its joints are 2 5-3 4 1. The leg rods are at an angle and not united. All the legs bear two like claws. There are but few dorsal hairs on any of the legs. The first leg has two hairs on the last joint and the second leg has one dorsal on the last joint, one on the next to the last and two hairs on the next joint. The last leg has one dorsal hair on the second, third and fourth joints and two on the fifth.

Basal appendages on the legs were very small. They were seen on the 7 last legs but may be on the others; they were .00425 mm. long by .00215 mm. wide.

Cerci.—These were .103 mm. long and one third as wide. There were fewer sense hairs on the base at its inner side. In all there were about 7 whorls of hairs of moderate length with eight transverse striations at the end of the appendage.

Terminal Sense Hair.—This is on a moderate elevation with three short hairs near its origin.

Locality.—Specimens were obtained in Live Oak Canyon, near Claremont, Calif., in May, 1929. The type in Pomona College collection is not quite mature, but seemed the best for

study and description. The sex openings and tracheal openings were not prominent.

Distinguishing Characters.—The peculiar sense spots on the antennae, the head rod, and the character of the mandibles are the most distinctive features. The strong chitinous rods connecting the legs except the first and the last are also marked, as are the rods of the first and the last from all the others.

***Scolopendrellina* new genus.**

The first body segment bears a well-developed leg only slightly shorter than the others. All claws even. The points of the dorsal plates sharp pointed but short. The first six segments of the body shortened and somewhat telescoped. The plates overlap much more than is usual. The head is slightly longer than wide, the antennae are with rather long hairs on both basal and tip segments. The head rod is heavy and unbranched except towards its base where it forks and at its forward end where it has branches almost at right angles. Each of these lateral branches meets a short longitudinal rod at the base of each antenna. The cerci are just slightly longer than the first leg and about twice as long as wide with about five whorls of moderately long hairs. The terminal hair lobe has a long hair and two shorter ones near. There is another lobe off from this which bears two small hairs. The jaws are not toothed and no basal appendages were seen on any leg.

***Scolopendrellina californica* n sp.**

(Figs. 4a, b, c, d.)

Length, 2.5 mm.

Head.—Length, .204 mm.; width, .153 mm. The head rod is strong, unjointed and branched only at its extremities. Posteriorly it is branched at a sharp angle but forward it branches almost at a right angle. Each branch forward is branched again almost at a right angle. The jaws are long and without separate teeth. The head bears quite a number of moderately short hairs, about 64 in all. The ocelli are nearly circular, .0148 broad by .107 long.

Antenna.—There are 17 joints in the type. The two basal segments have each a single whorl of hairs about as long as the segment and from that point on other segments for a distance have nearly two whorls of hairs. In the last two segments the hairs are shorter and more scattered. The terminal joint has a short sensory knob.

Scuta.—The first six segments are shorter than the others and somewhat telescoped. The body is fairly broad and the scuta also. The points are sharp but rather short. The first segment is .136 mm. wide and .107 mm. long; the second segment is .034 mm. long and .136 mm. wide. Between the spines the distance is .068 and the spines are .02975 mm. long. The third scutum is .085 mm. long, .17 mm.

wide with a distance between them of .0765 mm. Dorsally the first segment is short and without hairs. In the second segment there is a cephalic row of eight short hairs, two hairs on each spine and two short hairs between the spines. The third segment has a row of six, a row of four, three hairs between the spines and three on each spine. The following segments are somewhat similar. The last segment with spines has eight hairs in the cephalic and more central parts, two hairs on the spine and two hairs between the spines. The last segment has two lateral hairs and four caudal hairs.

Legs.—The first leg is .093 mm. long and .0297 mm. wide at the base. The leg segments are as follows beginning with the longest: 5-4-2-3-1. The second leg is .119 mm. long and .03 mm. wide, the joints are 5-4-2-3-1. The last leg is .154 mm. long and .0255 mm. wide. All claws are of equal size on each leg and usually rather blunt. No basal appendages were seen on the legs. The hairs were as follows. The first leg has a number of hairs near the claws and two prominent hairs on the third segment. In addition the second leg has a hair on the fourth joint and on the second joint. The last leg has a prominent ventral hair on the second segment a dorsal on the third, three on the fourth and four more or less on the dorsal surface of the last.

Cerci.—These are .101 mm. long and .0425 mm. wide, there are about five whorls of moderately developed hairs. There are about six cross striations on the tip of each of the appendages. The inner margin at its base does not bear hairs.

Terminal Sense Hair.—This is borne on a prominent lobe and has two shorter hairs at the base of the long one. A thick lobe or knob below the base of the hair bears two delicate hairs.

Locality.—Specimens were taken from South Hills near the city of Pomona. The type is in the Pomona College collection.

Important Distinguishing Features —As this is the first species described for the genus, many of the characters given may not prove to be specific differences. The head rod is distinctive, the length of the first pair of legs, the rather blunt claws of the legs, the rather hairy head, the overlapping of the first six segments of the body, the rather short but sharp points on the scuta are also remarkable.

Symphylella Silvestri.

Scolopendrella, Gervais.

The first pair of legs lacking or represented by a wart-like knob without claws. All setæ naked and slender. The last pair of legs with three long dorsal setæ on the metatarsus and at least three similar ones on the tarsus. Cerci large and well clothed with hairs.

***Symphylella isabellæ* Grassi.**

Many specimens from many distant parts of North America seemed to belong here as nearly as any place. Some of them differ from early descriptions of this species as well as from each other in minor points but after considerable study I have decided to place them here with some comments upon points of difference. In spite of many minor points which may later prove to be distinctive I am not as yet willing to describe any of these as distinct species.

Claremont, California, College Park. The head has about forty small hairs above. The head triangle has two hairs. The head rod is straight. The first segment has a row of six hairs. The second plate has a pair of cephalic backward pointing hairs. There are about 22 dorsal hairs on the first segment. There are 16 antennal joints. Total length, 2.5 mm.

Evey Canyon, near Claremont, California. The head is quite like the last, the second dorsal segment has a row of eight hairs. The second dorsal segment has no backward pointing hair but otherwise is similar to the last specimen but the points of the scutæ are not so sharp. Antennal joints 16 to 18 in specimens. Total length about 3 mm.

Redlands, California, (Several miles north). In these the terminal spines of the cirrus are rather long but no other marked feature was noted. Antennal joints 16, joints rather globular and flattened. Length, 3 mm.

Pudding Stone Canyon, near San Dimas, California. The most marked difference noted was in the fact that the first segment has but two hairs dorsally. The first segment has four rather large hairs before the spine, two more medial hairs, about four hairs on the spine and four hairs between the spines. The cirrus has a rather short curved terminal hair. Eighteen antennal joints and a body-length of 2.5 mm.

Laguna Beach, Orange Co., California, (North about a mile in a canyon). Like the others the head has numerous hairs. The head triangle has two hairs, the first dorsal plate bears six hairs. Prominent rods connect many of the legs. The basal segment of many of the legs have rather broad appendages. The two claws of the first pair of legs each bear three small teeth at their bases. The ocelli are about twice as long as wide. The cirrus bears a rather long terminal hair. Antennæ 16 to 18 joints. Total body-length, 2.5 mm.

Catalina Island, two miles west of Avalon. The head has fewer hairs than in some others, the eye spots are circular in outline. There is a moderately long terminal spine on the cirri. The first segment above bears four hairs. The second segment bears about 15 hairs above. Hairs are not so numerous on these specimens. The antennæ have 16 joints and a single whorl or rather short hairs. The total length is 3 mm.

Catalina Island, California, 20 miles north of Avalon. These are more hairy again. The head bears as many as 50 hairs above. The first body segment above bears 8 hairs. In some of the specimens the eye spots are circular, in others they are wider than long. The head rod has a number of branches at its cephalic end. There are two hairs in the little triangle back of the head in one specimen at least and in one at least there are but six hairs on the first body segment dorsally. The antennæ have 16 to 20 joints and the body length is 1.4 mm. in the specimen most studied but others are larger.

Live Oak Canyon, near Claremont, California. The head bears about 60 hairs, the head triangle two, the first segment dorsally eight hairs, the second segment dorsally about 24. One cephalic lateral hair points almost at right angle to the body. The eye is nearly circular in outline. Some of the leg claws seem slightly shorter than others. The terminal spine of the cirrus is quite marked. There are 20 joints on the antennæ and the total length of the body is 2.5 mm.

Bakersfield, California, (about fifty miles west in the hills). The dorsal hairs of the head are about 50. The head triangle has two hairs. The first body segment above has 8 hairs, the second about 25. The terminal hair of the cirrus is long. At the base of the terminal sensory hair are four very small spines. The antennæ are with 21 joints. The body length is 3.5 mm.

Santa Cruz Island at Pelican Bay, California. Hairs on the head triangle 2. The first segment dorsally has 6 setæ. The second scutum has four hairs in a cephalic row, four hairs between the spines and three hairs on each spine. The spine of the cirrus is long. The antennæ have 16 joints. The body length is about 2.5 mm.

Santa Cruz Island, Lady Harbor, California. The head has less than 40 hairs dorsally. The head triangle has two hairs. The first scutum has 4 hairs. The second has at least

20 hairs. In the specimen described the antennæ were broken. The total length was 1.2 mm.

Lower California, Mexico, about 50 miles from Tia Juana. The head had about 40 dorsal hairs. The head triangle two. The first scutum has a row of eight hairs. The second scutum has about 25 hairs. The ocellus is circular. The cercus has a short curved hair and in addition to the transverse striations there are minute dentitions on the side of the appendage near the base of the terminal hair. Antenna 14 joints but in this specimen they are apparently broken. The body length is 3.25 mm.

Lower California, Mexico, below Ensenada on the bay. The head has fewer hairs, about 30 above and two in the head triangle. The ocellus is one-fourth longer than wide. There are 18 joints in the antenna. The total length is from 2 to 3.5 mm. in the specimens collected.

Lower California, near San Tomas, Mexico. The head has quite a number of hairs, about 40 in all. The head triangle is without hairs in the specimen examined. There are from 17 to 19 joints in the antennæ and specimens were from 3 to 3.5 mm. long.

Symphylella vulgaris Hansen.

Specimens which seem to be this species were collected from the following localities, the most important variations are noted with each one. Indian Hill, Claremont, California. The head is moderately supplied with simple short hairs. The first segment dorsally has about ten hairs in a single row. The second segment has about 26 hairs. The last segment has about 12 hairs. The antennæ bear short hairs. The cerci have many moderately long hairs and the terminal part has seven cross striations. The terminal spine is short. There are 19 joints in the antenna and the total body length is 3 mm.

South Hills, near Pomona, California. There are about 20 hairs on the dorsum of the head, six on the first body segment, about 17 on the second scutum. Some of the basal leg appendages are conical, some are blunt. The Cerci bear rather short moderately heavy terminal spines. There are 21 joints in the antenna and the length is 4 mm.

Temiscal Canyon, California. There are rather fewer hairs on the dorsum than in some. The eye area is circular. The cerci are clothed in rather short hairs.

Corona, California. In a small canyon two miles west. The claws on the second pair of legs seems slightly uneven. On most of the legs the claws are even. Antennal joints 14, total length, 1.6 mm.

***Symphylella santa* n. sp**

(Figs. 5a, b, c, d.)

Length, 2.5 mm.

Head.—Length, .266; width, .200. There are about 26 hairs on the dorsum of the head and three hairs in the head triangle. The head rod is rather thick in the center, jointed behind where there are three branches, at its cephalic end there are branches at nearly right angles. The eye area is circular, .017 mm. in diameter.

Antennae.—These are 17 jointed in the type with few rather long hairs on the basal segments. They do not form a whorl until the third segment. The hairs are shorter than the segment to which they belong in the first and second segments. The hairs are longer than the segment in the third and others. The tip segments have very short hairs and several small sensory pits.

Scuta.—The first segment bears four hairs, the second about 14 hairs. Their sizes and proportions are about as in other specimens described from the island, but a distinctive feature is found in the fact that between the second and third, between the third and fourth, between the 6th and 7th and possibly some other segments there are especially long lateral setae not arising from the scuta but between them and extending latero-ventrally. The dorsal scuta are rather large and rather broadly pointed.

Legs.—The first to the third legs are .152 mm long, the fourth and fifth are .171 mm. long, the sixth .19 mm. long. The last legs are .266 mm. long. The last leg is provided with four hairs on the third leg segment two of which are dorsal. The fourth joint has about four cephalic hairs or about 7 in all. The last segment has at least three dorsal hairs. On the first foot and that of several others at least and including the last there seem to be three claws because of a short, rather heavy apical spine or hair. Basal processes were not noted on the legs.

Cerci.—These were .048 mm. wide and .228 mm. long. The hairs are rather irregular in about five whorls. They are also rather short. The cross lines near the tip are as usual and the terminal spine of moderate length.

Terminal Sense Hair.—This is on a well-developed lobe with two rather long hairs in addition to the longer terminal hair of the knob.

Locality and Material.—From Santa Cruz Island north of Pelican Bay.

Distinguishing Characters.—The long lateral setæ between some of the segments is especially remarkable. The apparent three-clawed condition of some at least of the feet is important. The head rod is of a distinctive type.

***Symphylella brevipes* Hansen**

Specimens from the following localities although differing in minor details seem to be of the above species.

Glen Ivy, about 50 miles from Claremont. The head bears about 32 hairs above. There are two hairs in the head triangle. The first dorsal plate has 8 hairs, the second 14 hairs. The head rod has a few small branches at its upper end and is forked behind with a small knob between the forks. The basal appendages are small and conical. There are 18 antennal joints. The total body length is 2.2 mm.

Big Pines, Mountains near Claremont, 7,000 feet elevation. The head has 24 hairs above. The head triangle has three hairs. The first segment above has six hairs. The second scutum has 14 hairs. Joints of the antennæ 15. Total length, 2.25 mm.

San Jacinto Mountains, Strawberry Valley, 7,000 feet elevation. Head above 32 setæ. Head triangle, 3 hairs. First thoracic segment has six hairs above. The second scutum has 18 setæ. The eye area is circular. All legs have two equal claws. Joints of antennæ, 18-24. Body length, 1.5 mm.

Mexico Valley. In some the head rod is wavy. The basal leg appendages are evident and usually truncate with at least one rather sharp spine at the end. The head triangle has no hairs. The ocelli are twice as wide as long. Sixteen to 19 joints in the antennæ. Lengths, 2 to 3 mm.

Cuba, 20 miles from Havana. Head rod simple as far as seen, claws even, rather hairy legs and body, all legs 2 equal claws. Antennæ, 15 joints. Length, 2 mm.

Cuba, near Matanzas. The last three legs seemed to have the claws somewhat uneven but all the rest seemed as usual. There were fewer hairs evident on the body than in the last. The ocelli are circular in outline. Seventeen joints on the antennæ. Total body length, 2 mm.

***Symphylella cubæ* n. sp.**

(Figs. 6a, b, c, d, e, f, g.)

Length, 2 mm.

Head.—Length, .2125 and width, .153 mm. The head rod is long and slender and seems unbranched forward but with three branches caudally, the central portion being thick and branched again. There are about 14 hairs on the head above. The ocellar area is circular and .02125 mm. in diameter.

Scuta.—The first body segment is rather longer than usual with about 10 setæ. The second scutum with its sharp points is possessed of about the same number of setæ.

Legs.—The first leg is .15 mm. long. The second leg is .539 mm. long. Several other legs are of about this length. The legs gradually increase in length and the last leg is the longest at .25 mm. long. The claws on the legs seem even or nearly so. The last leg has three cephalic spines or hairs on each of the last two joints. The second joint has two ventral hairs, the third joint has three prominent hairs. All the legs as far as could be learned possess a rather thick basal lobe which bears rather strong hairs. The basal appendage of the first leg bears 6 hairs. The appendage of the second leg bears 10 hairs, that of the third three large hairs and 16 minute hairs. The fourth bears 4 large hairs and many small ones. The fifth leg has 6 large hairs on its appendage. The sixth leg has four large hairs on its appendage. The eighth has 5. The appendage of the last leg has five marginal hairs coming from as many little serrations of the appendage.

Antennæ.—18-jointed. The basal segments have hairs about as long as they are in a single irregular whorl for each joint. The terminal joints have small sense pits and the tip joint is lobed and covered with fine hairs on its apex.

Cerci.—These are .1539 mm. long and one-fourth as broad at the base. The terminal region has about eight transverse striations and the terminal spine is about equal to the breadth. It is pointed but thick at the base in the type.

The Terminal Sense Hairs.—These are located in rather long lobes. One short hair is near the base of the large hair and several others near the body of the animal.

Locality and Material.—Artesia, Cuba. A number of specimens were collected. These and the type are in the Pomona College collection.

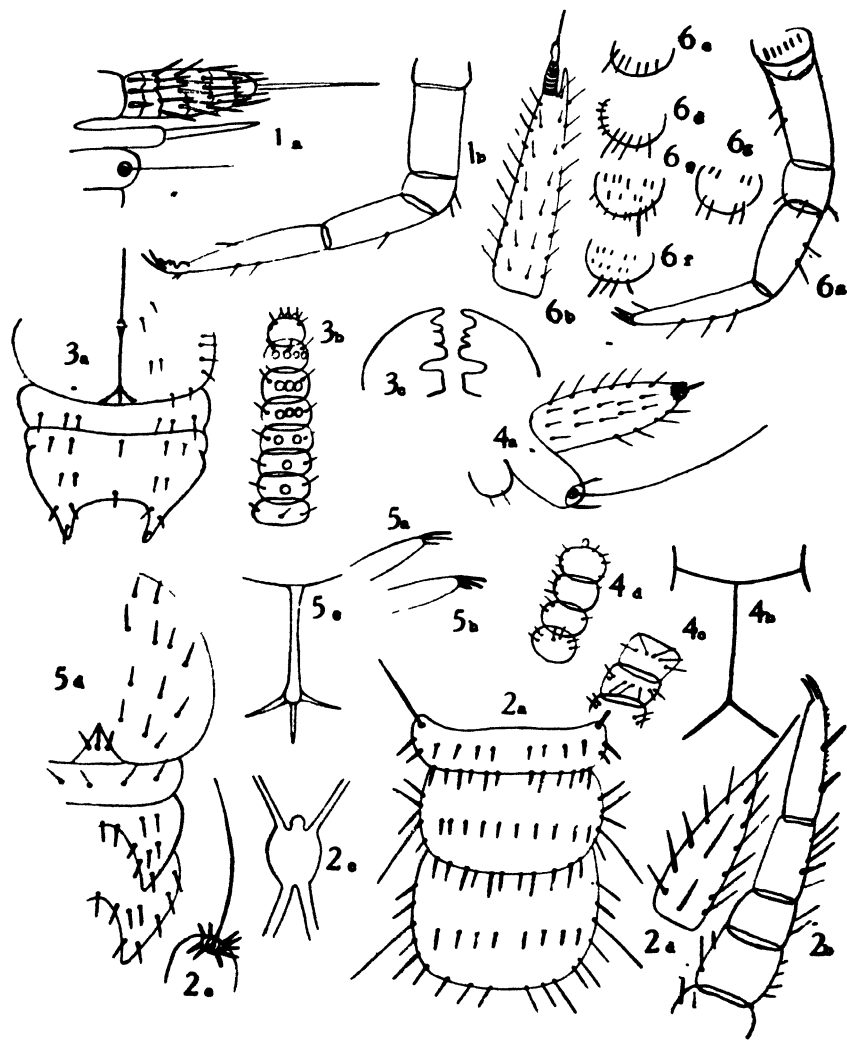
Distinguishing Characters.—The basal appendages of the legs are of a peculiar type. The head rod is rather distinctive. The last joint of the antennæ is peculiar.

BIBLIOGRAPHY.

- (1) Hansen, H. J. 1903. The genera and species of the Order Symphyla. Q. Jour. Mic. Sc. ns., v. 47.
 - (2) Bagnall, R. S. 1912. On a classification of the Order Symphyla. Jour. Linn. Soc., v. 32.
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EXPLANATION OF PLATE.

- FIG. 1. *Pseudoscutigerella americana* n. sp. (a) Side view of cercus and associated parts. (b) Last leg.
- FIG. 2. *Hansinella californica* n. sp. (a) First three thoracic plates from above. (b) Last leg. (c) Central part of head rod. (d) Cercus.
- FIG. 3. *Scolopendrellopsis sensiferis* n. sp. (a) Head and head rod with first two segments of the body from above. (b) Last joints of an antenna. (c) Jaws.
- FIG. 4. *Scolopendrellina californica* n. sp. (a) Lateral view of the cercus and associated parts. (b) Head rod. (c) Basal segments of antenna. (d) Tip segments of antenna.
- FIG. 5. *Symphylella santa* n. sp. (a) Tip of first leg. (b) Tip of the second foot. (c) The head rod. (d) Lateral part of the head and the first three segments of the body.
- FIG. 6. *Symphylella cubæ* n. sp. (a) Last leg. (b) Cercus. (c) Appendage of the first leg. (d) Appendage of the second leg. (e) Appendage of the fourth leg. (f) Appendage of the fifth leg. (g) Appendage of the sixth leg.



ACROTOMOPUS ATROPUNCTELLUS BOH. IN ARGENTINA SUGARCANE.

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INTRODUCTION.

While searching for parasites of the sugarcane moth borer, *Diatraea saccharalis* Fabr., in Ledesma, Province of Jujuy, Argentina, on February 20, 1929, larvæ of a Curculionid were discovered within several cane shoots. On returning to Tucumán, four live specimens were turned over to the Tucumán Experiment Station, and two were kept by the writer for rearing. On March 26, just a month later, the writer found a weevil borer in cane at the Tucumán Experiment Station which proved to be the same species as the Ledesma specimens. These were the first records of any such weevil occurring in sugarcane in the Provinces of Jujuy and Tucumán. Inasmuch as there are weevil borers doing considerable damage in South America and in other parts of the world, it was thought best to make further observations on this species.

From the larvæ collected in the cane, adults were reared and sent to Dr. Carlos Bruch at Buenos Aires, who very kindly tentatively determined these as *Archarias atropunctellus* Boh., having compared them with specimens in his collection named by Hustache as *Acrotomopus atropunctellus* Boh. Dr. Bruch stated that this species was originally described by Boheman¹ as *Cholus atropunctellus*, and that his specimens were obtained in Tucumán and Santiago del Estero on corn, being listed in his catalog² under *Archarias* Lac., having been determined as such by Dr. Heller from other specimens in Dr. Bruch's collection. Dr. Bruch further stated that in no case was it *Cholus*, but either *Acrotomopus* or *Archarias*. Dr. G. A. K. Marshall, who has examined the Tucumán specimens, places the species in *Acrotomopus*, where it doubtless belongs.

¹Boheman in Schonherr, Gen. Curcul, III, 1836, p. 570.

²Bruch, Carlos, Coleoptera of Argentina, Part 7, 1915, p. 422.

DISTRIBUTION.

This weevil seems to be generally distributed throughout the cane-growing region in Argentina, as both larvæ and adults have been obtained from several different points. However, it has not been found in any great numbers except at Ledesma, Jujuy, and at Rio Chico, Tucumán.

EGG.

In only three instances were eggs of the weevil found; two of these were found on April 24, 1929, at Rio Chico, and the other one at Ledesma on January 10, 1930. These were found in small tender shoots of cane which had turned slightly brown and which had been punctured in three or four different places. Upon cutting open these cane shoots the eggs were found to be in the center of each shoot. The egg was creamy white and cylindrical, being about one millimeter in diameter. Those from Rio Chico were photographed the following day (Plate I, Fig. 4), and set aside for rearing. However, three days later the cane containing these eggs had become covered with a fungus and the eggs had disintegrated. The egg from Ledesma was broken in handling.

No other eggs were obtained, though several shoots of cane which showed injury by the adult weevil were examined from time to time. Several adults were placed in cages containing growing cane, but although all the shoots were punctured and later showed the injury characteristic of the weevil, none contained eggs or young larvæ upon examination.

LARVA.

The larvæ are found within the cane throughout the entire year, there being only one generation each year. The larva found on February 20, 1929, which was about half grown, did not produce an adult until eight months later, October 22, and those collected on April 24, the fall of the year, did not produce adults until November and December. The emergence from these larvæ, which were kept in the laboratory over the winter, was the same as from those larvæ collected in the spring which had wintered in the field, the majority emerging in November and December. The larvæ pass the winter in the lower portion of the shoot, going down two and three inches

below the surface of the ground in the stool of the cane, (Plate I, Fig. 3). It is often found that a larva has bored down one shoot and come up another, and sometimes the center of the stool has been considerably eaten. The number of molts that the larvæ pass through could not be determined as none was reared from the egg to the adult. There was a large variation in the size of the larvæ collected, and upon measuring the width of the head capsule of 23 larvæ there was a variation in size of from 0.09 millimeters to 2.25 millimeters. There appeared to be 6 distinct groups, the average of each being 1.0 mm., 1.3 mm., 1.55 mm., 1.75 mm., 2 mm., and 2.4 mm. There was very little difference in size of head capsule in any one group, but in size of body they varied from smaller than the preceding group to larger than the following group.

PUPA.

The larvæ transform to adults by passing to the pupal stage in the lower portion of the cane shoot, having first bored a tunnel to the outside of the cane so that when the adults have formed they can escape. Of those larvæ kept in the laboratory, two required 14 days from the time the pupa was first formed until the adult emerged, while a third required only 7 days.

ADULT.

The adult weevils obtained by the writer ranged in length from 10 to 14 millimeters, being a light dull granulated brown color. (Plate I, Figs. 1 and 2). The technical description by Boheman follows:

"Oblongus, niger, albido-squamosus, thorace antierius minus angustato, punctato, remote granulato, utrinque in medio dorsi leviter impresso, basi sub bisinuato, elytris subtiliter punctato-striatis, interstitiis remote nigro granulatis.

Habitat in America meridionali. A Dom Ménétriés missus. Mus. Schh.

Reliquis angustior, sub-cylindricus. *Cholo pistori* fere aequalis, sed duplo fere angustior. Caput mediocre, rotundatum, nigrum, squamulis albidis remote, supra oculos dense obsitum; vertice remote subtiliter, fronte profundius punctatis, oculi ovati, transversi, haud prominuli, nigri, rostram longitudine capitis cum thorace, deflexum, minus crassum, teres, arcuatum, apicem versus nonnihil ampliatur, nigrum, sub-nitidum, basi carinula abbreviata instructum, undique sat crebre punctulatum. Antennæ mox pone medium rostri insertæ, tenues, nigro-piceæ, albido-pilosæ, clava parva, oblonga-ovata, dense

cinereo-pubescente. Thorax latitudine baseos vix longior, apice truncatus, anterieus parum angustatus, lateribus modice rotundato-ampliatus, basi leviter hisinuatus, angulis baseos retrorsum nonnihil prominulis, supra parum convexus, minus crebre punctatus, granulis remotis, nigris, denudatis, adpersus, in medio dorsi utrinque foveola parum profunda impressus; totus niger, squamulis dilute paleaceis tectus. Scutellum parvum, rotundatum, nigrum, punctulatum. Elytra sub-obconica, basi conjunctim introrsum leviter emarginata, antice thorace fere angustiora, quam lata triplo longiora, humeris vix prominulis, fere rectangulis, a basi apicem versus perparum sensim angustata, apice ipso conjunctim obtuse rotundata, supra modice convexa, ante apicem gibbere obtuso notata, regulariter, etsi subtiliter, punctato-striata, interstitiis planis, remote seriatim nigro granulatis; tota nigra, squamulis unicoloribus paleaceis dense tecta. Corpus subtus nigrum, squamulis albidis sub-argenteis dense vestitum. Pedes elongati, nigri; anticis longioribus; squamulis albidis adpersi; femoribus modice clavatis, subtus ante apicem dente parvo, oblongo, armatis; tibiis nonnihil arcuatis, apicem versus ampliatis; tarsis dilatatis, subtus fulvo-spongiosis.—B.H.N."

During the season of 1929 and 1930 the first weevils probably appeared in the field during the middle of November, according to the rearing records, but the first adults were not found until December 6, at Rio Chico. On this date not an adult was found from 11 A. M. to 2 P. M., although sweepings were made, the cane carefully searched, and several injured shoots cut open for examination. However, from 2 P. M. to 3 P. M., six adults were found either sitting on the leaf in plain view or down in the sheath next to the stalk.

On December 9 one adult was found on cane near Ingenio San Felipe, Tucumán, and on December 14 another was found near Ingenio Concepción, Tucumán, but at Ledesma on January 10, 1930, 24 adults were found in the cane within one hour. These were all located within one field. There were eight found in pairs of two, the others being collected as individuals, except in one case where there were four found all on the same cane sheath.

The adults play "dead" or "possum" when disturbed, often dropping to the ground, and are then hard to see owing to their brown color. They also go down between the leaf sheath and stalk, being almost entirely out of sight. It was observed from those kept in cages for experiments that they went down into the cracks in the soil. In one case where an old hollow stub of cane was in a cage, three adults were found in it on examination.

INJURY.

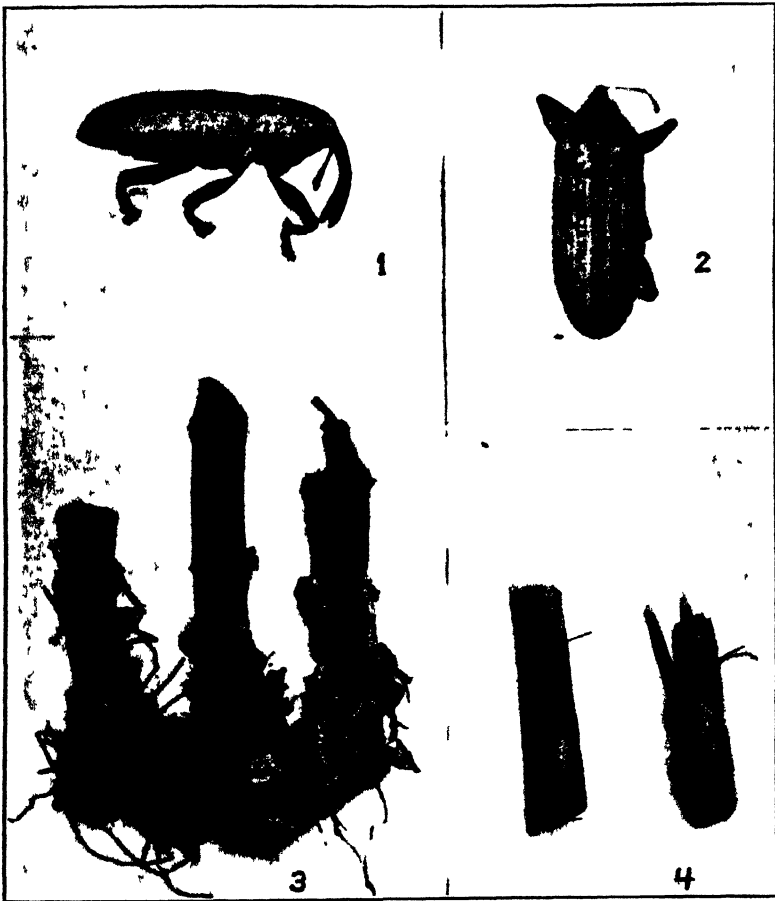
The adults kill a large number of the young cane shoots by puncturing them for food. These are small, rough-edged punctures and are distinctly different from a *Diatraea* borer hole. The shoots that have been punctured for food, and also those containing young weevil larvæ, become brown and die. The outside leaves become dry as well as the center leaves, thus distinguishing this injury from the characteristic "dead-heart" injury of the *Diatraea* borer, which at first turns yellow only in the center.

The number of shoots injured by the weevil in obtaining food is more noticeable earlier in the season (the first part of December) than later. This is due to the fact that the young side shoots punctured early in the season turn brown and die, while later they have fallen amongst the trash and are not noticeable. Also, later in the season the side shoots are larger and stronger and do not turn yellow unless considerably punctured or eaten by larvæ.

The weevil larva makes a large-size tunnel through the cane, leaving the burrow full of frass which makes it easily distinguishable from the tunnel made by a *Diatraea* borer.

In one field at Ledgesma where there was a large infestation of the weevil, the upper part of the cane looked green and healthy at a distance, but upon closer examination the lower half appeared to be drying up for lack of water. This drying was due to the fact that about 40 per cent of the side shoots contained larvæ of the weevil. These shoots were at this time about three quarters of an inch in diameter and from two to three feet high. At another time, upon examination of ten stools in one row of cane, 16 weevil larvæ were found, and several of the side shoots showed injury but contained no larvæ.

Two larvæ have been found in the same shoot, but inasmuch as they are of cannibalistic habits, and the tunnel occupies most of the space in the smaller shoots, there is not room for more than one, and the larger or stronger usually eats the others that may occur in the same stalk. Two larvæ of the same size were found dead next to each other, each having been partially eaten by the other.



- Fig 1 Lateral view of adult of *Acrotomopus atropunctellus* Boh.
Fig 2 Dorsal view of adult of *Acrotomopus atropunctellus* Boh.
Fig 3 Larvæ of *Acrotomopus atropunctellus* Boh during hibernation in root of sugar cane
Fig 4 Egg stage of *Acrotomopus atropunctellus* Boh. in center of sugar cane plant

PARASITES.

From 19 weevil larvæ that were cut from young cane shoots on April 24, 1929, at Rio Chico and placed in individual pieces of cane for rearing, two fly puparia were obtained. One of these puparia was formed by May 23, while the other was not formed until October 8, the adult of which emerged on October 26, 1929.

On October 22, while again looking for weevil borers in Rio Chico, 16 live borers, 1 good fly puparia, and 2 empty fly puparia were found. These puparia were found in tunnels previously made by the weevil borer. From the good puparia the fly emerged on November 7.

It will be seen that the percentage of parasitism in the first lot was 10.5 and in the second lot 14.7, or an average parasitism of 12.6 per cent.

The flies reared were sent to Dr. Aldrich, of the U. S. National Museum, who kindly determined them as *Paratheresia claripalpis* Van der Wulp. This is the same fly which parasitizes *Diatraea saccharalis* Fabr. to such a large extent in both Argentina and Peru³.

This was the only parasite found attacking the weevil larvæ, and so far no indications of any other parasite have been found.

ECONOMIC IMPORTANCE.

There is a possibility of this weevil increasing in sufficient numbers to cause noticeable damage to the cane, such as was seen in Ledesma and Rio Chico. An extremely heavy infestation of weevil larvæ would cause considerable damage to the cane stools over the winter, and also to the young cane shoots in the spring. As the weevil appears to be widespread throughout the sugarcane region of Argentina and so far has done damage only in small localities, it may be that it is more or less controlled by its parasites. However, it should be watched to determine whether or not its increase is general or only spasmodic.

³Jaynes, H. A. Notes on *Paratheresia claripalpis* Van der Wulp, a Parasite of *Diatraea saccharalis* Fabr. Jour. Econ. Ent., Vol. 23, No. 4, August, 1930, pp. 676-680.

PRELIMINARY STUDIES OF THE INTERNAL STRUCTURES OF *BRAULA COECA* NITZSCH.*

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INTRODUCTION.

The first mention of this insect was made in 1740 by Reamur (9), who discussed its relation to the honeybee. Nitzsch (1818) described the genus and species, naming the insect *Braula coeca*; and classified it, on account of its mouth parts, with the Diptera, associating it with the Pupipara. Errors in Nitzsch's description of antennæ and thorax were corrected by Egger (4), thus removing any doubt as to the alliance of *Braula* with the Diptera. Since *Braula* did not fit into any insect classification then in use, Egger proposed the special family, Braulidæ. According to Muggenberg (7), the structure of the head vesicle shows a close relationship between *Braula* and the Hippoboscidæ. Taxonomically, Handlirsch (5) removed the *Braula* from the Pupipara and placed it in a separate family next to the Phoridæ. It was formerly generally believed that *Braula coeca* was pupiparous but, according to Muggenberg (7), Skaife (10), Arnhart (2) and Argo (1), it is oviparous. Skaife and Argo described fairly completely the life cycle of the insect, while Arnhart found the mines and dried out larval skins under honey cappings. Perez (Phillips 8) found that *Braula* was not a true parasite, as believed by the older workers, but that it was a sort of commensal parasite feeding on the nectar which it steals from the honeybee. Muggenberg (7) described the mouth parts and discovered the eyes of the supposedly blind insect in 1892. Börner (3) gives a detailed account of the external morphological structures. Skaife (10), through microdissection studies, described in a general way the alimentary canal and the male and female reproductive organs. He also worked out the metamorphosis of this insect.

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MATERIAL AND METHODS.

The specimens of *Braula coeca*, preserved in 70 per cent alcohol, were obtained from Mr. Oswald Muck of Vienna. They were gradually changed from 80% to 95%, and finally, for dehydration, to 100% alcohol. They were then cleared in Xylene. Paraffin, at a melting point of 54-56° C., was used for infiltration and imbedding. The sections were cut at 7 microns. Half of the serial-sections was stained in Mayer's Haemalum and counter-stained in aqueous eosin, the other half was stained in Iron Haematoxylin and counter-stained in aqueous eosin.

Sectioning of the heavily chitinized insects was carried on with difficulty, the brittle chitin shattering on the edges, giving a distorted view of some of the internal parts close to the chitin. Sometimes entire sections shelled out. Two series, out of the 16 sectioned, were complete. The remaining series, although incomplete, afforded checks on various details of the structures which had to be determined.

THE BODY-WALL AND ITS APPENDAGES.

The body-wall of *Braula coeca* consists, in the outer part, of a heavily chitinized cuticula, interrupted only at the movable joints by a soft intersegmental membrane. The cuticula is made up of two main layers—the outer, harder layer or the primary cuticula, and a softer, inner layer, or secondary cuticula. The cuticula varies greatly in thickness, approaching its maximum density around the epicranial capsula and the dorsal part of the mesothorax. Heavily chitinized invaginations, e.g. the ptilinum, or the openings of the genitalia, have a modified cuticula bearing numerous soft spines which give to it a furry appearance.

Practically every part of the body is covered by sensory hairs of varying lengths and diameters, which are inserted in sockets and joined to the cuticula in such a manner that they are movable. These sensilia originate from an innervated hypodermal cell and are hollow nearly to the tip (Fig. 1).

The hypodermis consists of a single layer of somewhat flattened cells which are evenly distributed over the entire body-wall. These hypodermal cells are distinctly nucleated, the nuclei being oval in shape and staining fairly well.

The basement membrane, underlying the hypodermis, is a thin, structureless sheath, interrupted only by the muscle insertions and by the nerve-fibres leading to the sense organs.

The pulvilli of *Braula* are located at the terminal point of the last tarsal segment, above the comb-like arrangement of claws. When walking on a smooth surface the insect turns the claws inward, thus gaining the full use of the pulvilli. The cuticula of the pulvilli is interrupted by many hollow tenent hairs, each of which connects at its base with a gland cell. At the distal end of each tenent hair a minute, bladder-like organ may be seen (Fig. 10).

MUSCLES AND ENDOSKELETON.

The muscles of *Braula coeca* are all of the striated type. Every muscle fibre represents a compound cell with many strongly-staining nuclei. These muscles are attached to the body-wall by interlocking with the hypodermal cells (Fig. 2) or epithelial cells at invaginations (Fig. 3).

No sign of an endoskeleton was found in the head or dorsal half of the thorax of this insect. In the median line of the ventral surface of the thorax arise the furcæ, heavily chitinized plates, which join each other to form a ridge. This ridge approaches very close to the thoracic ganglia, extending almost through the entire length of the thorax. Lateral apodemes arise between the coxæ and join the furcæ, forming partial cross-plates. The furca widens and reaches its greatest thickness just behind the metathoracic ganglion, on the ventral side of the connective, which extends to the abdominal ganglion. This endo-thoracic projection serves for muscle attachment.

THE NERVOUS SYSTEM.

The nervous system of *Braula* (Fig. 7) consists of the brain, the sub-oesophageal ganglion, three paired and closely united thoracic ganglia, one abdominal ganglion, and the connectives between these.

The supra- and sub-oesophageal ganglia appear as a mass through which the oesophagus passes. From the supra-oesophageal ganglion extends:

1. The optic nerve, which is very thin, leads to an inconspicuous eye, which was first discovered by Muggenberg (7). At the terminal point of the optic nerve, very slightly different

from the hypodermal cells and protected by a cuticular invagination, there is a group of cells, arranged radially, which constitute the internal eye. Apparently there is a dark substance present among the optic cells, which may be pigment. The eye is visible externally, just above the antennæ, as a pale spot on the cuticula, surrounded by a more darkly pigmented chitinous ring.

2. The heavy antennal-nerves also start from the supraoesophageal ganglion and they branch immediately after entering the antennæ.

3. Another pair of nerves from this ganglion innervates the labium.

The suboesophageal ganglion sends out only two pairs of nerves—both of them large—the maxillary and the labial nerves.

The ganglia, when sectioned, are finely granulated and are surrounded by small cells with darkly staining nuclei. This surrounding layer of cells varies in thickness.

Slightly above the oesophagus, there extends forward from the brain two thin, arched nerves which meet and form the *frontal ganglion*. From the frontal ganglion a single unpaired nerve extends backwards along the oesophagus and finally terminates at the mid-intestine.

The connectives (Fig. 7) leading from the suboesophageal ganglion through the cervical region into the thorax, are so closely approximated as to form a cord. Here it enters the thoracic ganglion mass. From the lateral sides of each of these three thoracic ganglia, the most conspicuous structures are a pair of large nerves leading ventrally, each pair entering a pair of legs. From the caudal end of the thoracic ganglionic mass, a stout and short connective leads into the abdomen.

The abdominal ganglion is unpaired and sends out several branches. The hind-most, and largest pair of these branches terminates in the reproductive organs.

Numerous small branches originate from the various ganglia that innervate the sensory hairs on the body periphery (Fig. 7) and the closing-apparatus of the spiracles. Other branches lead to the secretory and excretory organs, as well as to the heart, the intestines and the muscles.

THE ALIMENTARY CANAL AND ITS APPENDAGES.

Skaife (10), through a binocular dissection study, determined the divisions in the alimentary canal, and illustrates them with a series of drawings.

Fore-Intestine.—The mouth of *Braula coeca* consists of a heavily chitinized invagination that gradually narrows down to the pharynx. The pharynx extends upward as high as the antennal cavity turns towards the anterior wall of the head (Fig. 5), then slightly downward and then suddenly upward, running a short distance along the body-wall, to which it is attached by muscles. A posterior turn leads the oesophagus between the supra- and sub-oesophageal ganglia into the thorax, where it widens and divides into two passages, one leading into the crop, the other through the proventriculus, into the mid-intestine.

The crop (Fig. 5) is a large, thin-walled vessel which fills the major part of the abdominal body-cavity. It represents a food reservoir of vast capacity.

The oesophagus extends forward, within a short distance of the mid-intestine, loops backward for a short distance, gradually thickening in size, then loops forward, tapering down and bending in such a manner that the loops form the proventricular valve. The mid-intestine begins at the posterior end of the proventricular valve.

The layers of the fore-intestine are:

1. The Intima. Starting as a chitinous layer of considerable density, it gradually becomes thinner to form a fine membrane in the oesophagus. As crop-lining, it is so thin that it can only be observed with difficulty (Fig. 4).

2. The Epithelium. From the mouth, through the pharynx and oesophagus, the epithelium consists of flat, cuboid cells with oval, well-staining nuclei. These cells gradually flatten out in the oesophagus to a point where the cell-dividing membranes disappear. The epithelial cells of the crop-wall are depressed to such an extent that the nuclei are spaced a considerable distance apart. In the proventriculus, the epithelial cells attain their greatest dimensions and have large circular, strongly-staining nuclei. The cytoplasm of the epithelium of the proventriculus also takes the stain readily, showing a fine granulation.

3. The basement membrane. This underlies the epithelium, and is a continuous, nearly structureless, layer, closely resembling the basement membrane of the body-wall. The basement membrane is so reduced in the crop that it can barely be differentiated from the longitudinal muscle layer.

4. The muscle layers. These lie next to the basement membrane and are in two layers, one longitudinal, the other circular. Both of these muscle layers are well developed in the pharynx and in the anterior end of the oesophagus. After the oesophagus passes the brain, they are much reduced in size. Around the crop both the longitudinal and circular fibres are spread apart, producing, thus, a net-like structure. There is a considerable increase both in number and in size in the fibres of the two muscle layers around the proventriculus. This is probably due to the necessity for musculation of the proventricular valve.

The intestinal muscles are striated. They show the same staining properties as the other muscles, but are not as regularly nucleated. The nuclei are oval in shape, very small, and present a group of two or three chromatin granules. These characteristics of the intestinal muscles apply to all the regions of the alimentary canal.

4. The peritoneal membrane. This is a thin structureless layer, which is penetrated only by air-supplying trachea and nerves and which envelopes all parts of the intestines.

Mid-Intestine.—The mid-intestine extends from the oesophageal valve to the place where the Malpighian tubules enter. The wall is of considerable thickness, having frequent transverse infolds. The mid-intestine is made up of the following layers: A digestive epithelium, with dark staining-plasma and large circular nuclei. The nuclei have numerous small chromatin granules. The cell-walls, however, are indistinct, probably due to fixation methods (Fig. 8). Underlying the epithelium is the basement membrane. This is followed by two layers of muscles, which are surrounded by a peritoneal membrane.

The muscle layers of the mid-intestine differ from those of the fore-intestine by their reversed position. There is a circular layer surrounded by a longitudinal layer. A thickening of these muscles, and more compact arrangement, can be observed where the mid-intestine narrows down at the junction with the hind-intestine.

Malpighian tubules.—Skaife (10) found four Malpighian tubules in *Braula coeca*, two on each side pairing to form a single tube before they enter the hind-intestine. The same arrangement was found in other Diptera (Hewitt's (6) description of *Musca domestica*). These tubules are long and slender, winding their way around the viscera. They are found in almost any position in a section, e.g. along the side of the heart, close to the genital organs, on both sides of the mid- and hind-intestine. In one section, due to their convolutions, eleven cuts through these vessels were counted. The tubes are of uniform thickness from their starting point to their blind ending, no reduction in the diameter taking place after the branching. There are only two distinct layers visible, an epithelium and a surrounding membrane (Fig. 6). no sign of an intima was observed. The Epithelium consists of a layer of large cells with indistinct cell wall. In only a few cuts were these cell walls visible. The cells are of such dimensions that only two or three are visible in a cross-section through a tubule. The cytoplasm of these cells shows a variety of staining reactions, as though the cells were in a different state of function or development. The dark-staining nuclei have a swollen, succulent appearance. There are visible, in each nucleus, one or two large granules of chromatin and many smaller granules. The tubules are enclosed by a thin, well-stained, structureless membrane. The lumen is continuous, its size varying in accordance with the size of the epithelial cells. No muscles, whatever, were visible on the Malpighian tubules.

Hind-Intestine.—*Braula coeca*, unlike most other insects, does not show any regional divisions of the hind intestines. Starting from the narrow restriction, at the mouth of the Malpighian tubules, the hind-intestine suddenly enlarges and shows no further restrictions until it narrows down to form the anus (Fig. 5). The hind-intestine is lined by an intima which is continuous with the cuticula at the anal opening. Outside of this is an epithelium with indistinct walls, apparently a syncytium. The plasma of this epithelium exhibits fine granulation which does not stain as well as it does in the fore- and mid-intestine. The epithelial nuclei are far apart, of small size and strongly stained. There is an evident thickening or swelling around these nuclei, thus rendering the intima tuberculate in appearance (Fig. 9). The epithelium is lined by

a basement membrane, next to this are the three muscle layers: First, the ental-circular muscle layer; then the longitudinal muscle layer; and, finally, the ectal-circular muscle layer. The arrangement of these muscle layers is of a peculiar type. The two circular layers are so similar that it would be impossible to distinguish them from each other, if it were not for the longitudinal muscles interspaced between them. The peritoneal membrane encloses the entire hind intestine.

Skaife (10) observed, in the hind-intestine of *Braula coeca*, four rectal glands, all well supplied with tracheæ. These are similar to the findings in other Diptera, i.e. Hewitt (6) in *Musca domestica*. These four glands are circularly arranged in the anterior part of the hind-intestine. They are attached to the wall and hang into the lumen of the intestine. Each gland has a circular base and exhibits a pouch-like shape. Externally there is a perforated chitinous layer which is continuous with the intima of the hind-intestine. The cavity of the glands is filled with loose, branching cells (Fig. 5). Every one of these cells has a large nucleus with one or two large, well-stained chromatin granules. There is visible, at the base of each gland, a mass of cells with smaller-sized nuclei, and without any distinguishable cell membranes. The lumen opens into the intestine through the perforations in the chitinous membrane. The cytoplasm of the gland cells shows a fine granulation and large vacuoles. The tracheæ entering the glands, send out branches which penetrate the cell membranes.

Salivary Glands.—One pair of salivary glands is present in *Braula coeca*. This pair is situated in the thorax, one gland on the left and the other on the right, slightly posterior to the proventriculus. The salivary gland of this insect represents a spindle-shaped arrangement of glandular cells, enclosing a lumen (Fig. 11). A duct extends ventrally from the lumen, joining the duct of the other gland ventrad of the connective and cephalad of the prothoracic ganglion. The single duct proceeds, from the point of junction, in a cephalic direction, and passes through the cervical region (Fig. 5), where it turns ventrad and extends along the sub-oesophageal ganglion. The salivary duct thickens, as though it is forming a reservoir, after it enters the head. The duct narrows again, after entering the labium, bends slightly forward and opens, from the lower part of the labium, into the mouth.

Each salivary gland consists of a single layer of glandular cells, circularly arranged around the lumen. They are elongated cuboid cells with dark-staining nuclei, of a swollen and succulent appearance (Fig. 11). The nuclei vary from circular to oval in shape. The cell walls are very distinct. The cytoplasm is strongly granulated and takes the stain readily on the free edge of the cells, the color gradually becoming more faint as the lumen-edge is approached. A structureless basement membrane surrounds the gland and continues to envelope the duct. No chitinous structure, underlying the glandular epithelium, could be observed. The salivary duct, the paired ducts, and the single duct each consist of three layers: A chitinous layer, modified like a spiral taenidium (Fig. 11), lines the interior of the duct. This structure is very similar to the taenidium of a trachea but lacks the spiny projections which are characteristic of the tracheal taenidia. The next layer is the much-flattened epithelium, with small nuclei spaced far apart. No distinct cell walls could be observed. A basement membrane surrounds the entire duct.

RESPIRATORY SYSTEM.

The number, and the location, of the spiracles in *Braula coeca* have been discussed and illustrated by Börner (3). The male and female have the same number of pairs, namely: 5 abdominal, 1 meta- and 1 meso-thoracic. The five abdominal spiracles are situated on the last five oblique pleural plates of the abdomen. The meta-thoracic spiracle is on the posterior narrow edge of the meta-sterum. The meso-thoracic spiracles have moved dorsad so far that they are visible, not only laterally, as circular punctures, but also dorsally as semi-circular indentations, on the edge of the ventral mesonotum. The abdominal and meta-thoracic spiracles are small and inconspicuous. The spiracles are surrounded by a circular peritreme.

A cross section through a spiracle (Fig. 12) shows that the peritreme covers a tiny vestibule with smooth chitinous walls which are directly connected with the cuticula. The exterior end of the vestibule is closed by a thin, chitinous plate, which has a slit in the center. The slit ends overlap each other to form a trap-like opening. A second chitinous ring, with a small opening, is situated at the interior end of the vestibule. The slit in the second ring leads into a second chamber, whose wall is densely covered with fine hair. At the interior end of

this second chamber is a third ring and closing apparatus. The tracheæ lead inward from this second vestibule. A muscle and nerve fibre are attached to the closing apparatus. The spiracular invagination is lined with an epithelium which is supported by a basement membrane. These layers are continuous with the lining in the tracheæ.

The mesothoracic spiracle is much larger in size than any of the other spiracles but it is not surrounded by a distinct peritreme (Fig. 14). A large, circular opening leads into a large, round vestibule. Many hairs project inward from the chitinous walls of this vestibule, thus forming a hair-filter. At the inner end of this chamber are two chitinous rings, a small and a large one respectively, having circular openings in the center. These openings lead into a smaller, cylindrical chamber, which has smooth chitinous walls and which widens at the end where the closing apparatus is situated. A nerve and a large transverse muscle control the functioning of the closing apparatus. The trachea leading away from this spiracle into the interior part of the body, has about three times the diameter of the tracheæ of the other spiracles.

A trachea is made up of three layers: 1. A chitinous taenidium, spirally arranged, sending out spine-like projections in a radial arrangement towards the center of the tube (Fig. 20); 2. An epithelium, which surrounds this taenidium and consists of much flattened cells with round and flat nuclei; (The nuclei contain two or three chromatin granules. The plasma in the epithelial cells stains very slightly and has a homogenous appearance. One cell may circumferentially differentiate a tracheal cross section) 3. and finally, a structureless basement membrane very similar to the one in the body wall.

The tracheæ leading into the body cavity branch immediately, the smaller branches passing directly to the various organs, the larger branches joining a main trunk that runs longitudinally through the body. This trunk reaches its largest dimensions in the thorax, at the junction with the extremely large trachea, coming transversely from the mesothoracic spiracles. Numerous branches from this pair of tracheal trunks provide an air supply for the various organs. These trunks extend into the head, passing the cervical region on the left and on the right of the ganglionic connective. In the head, these trunks divide into numerous branches, of various sizes, supplying air to the head regions.

THE HEART AND EXCRETORY ORGANS.

The heart of *Braula coeca* is a thin-walled, flattened tube, which extends from the beginning of the fifth abdominal segment to the thorax. It consists of five chambers and has four pairs of lateral openings (ostia). The wall of the heart takes a slight stain (Fig. 17). The first chamber is very short and is situated ventrad of the conjunctive of the fourth and fifth abdominal segment. It is a blind chamber, rounded at the posterior end. The other chambers are longer, adapting themselves to the length of the abdominal segments. The second, third and fourth chambers are similar in length and shape. There is a gradual reduction in width from the beginning to the center of each chamber and then gradually enlarging, until the infolding in the wall of the vessel forms an ostium, which structure marks the beginning of the following chamber. The fifth chamber is narrower and shorter than the previous ones, extending from the fourth pair of ostia to the caudal end of the aorta, approximately at the point where the thorax begins (Fig. 5).

Underneath the heart are a number of non-striated, slender, longitudinal muscle-fibres connected with each other by a fine, structureless membrane (Fig. 18). The course of the heart in the abdomen is not straight, slight convolutions occurring frequently. These convolutions are apparently caused by the pressure which is exerted against it by this filled crop.

The Aorta.—The aorta begins at the junction of the thorax and abdomen as a slender circular tube. It widens rapidly to form a thoracic ampulla, which bends ventrally (Fig. 5), narrows down, and, finally, is reduced to the normal-sized aorta. The aorta passes through the cervical region, above the oesophagus, into the head. In the head it turns dorsally, running close to the supraoesophageal ganglion until it reaches almost as high as the brain. The aorta opens, after a slight forward turn, very close to the brain.

The Pericardial Cells.—On both sides of the heart is a row of large cells. These are arranged in single-file formation, although occasionally a few of these cells bunch together (Fig. 17). In *Braula*, the pericardial cells are large and mononucleate. The nuclei vary from circular to oval. Others show a distinct bilobing (Fig. 19). The nuclei exhibit large, extremely dark-staining chromatin granules. The cytoplasm is granular

and vacuolated. The vacuoles show still finer granula. The nuclei are surrounded by an assembly of bodies, varying in shape, round or angular, which do not take any stain. These bodies, according to their location, appear black or yellowish-transparent. Between the pericardial cells, muscles and fat bodies, there are weakly staining fibres.

The Fat Bodies.—Fat bodies, varying in size, appear in all parts of the body. In general they are directly beneath the hypodermis and appear much flattened. Lobes, varying in dimensions and shapes, surround most of the organs. The fat bodies assume the form of the space available. The abdomen, with the exception of the dorsal surface, contains few fat cells, due to the fact that intestines and the genitalia fill nearly the entire body-cavity and leave very little room for adipose tissue. These fat bodies always contain two or more nuclei (Fig. 15). The dividing walls between the fat bodies are very indistinct. The nuclei are large in size and contain strongly-staining chromatin granules, of all sizes, loosely arranged. The cytoplasm shows fine granules, interrupted by numerous fat vacuoles, of varied shapes and sizes.

Oenocytes.—Oenocytes occur in various places in the body cavity in the same position as the fat bodies. Sometimes they are near the hypodermis and sometimes near the tracheæ. They appear to be closely associated with fat-cells, sometimes entirely surrounded by them. The oenocytes are found in groups ranging from two to eight. When they are not crowded, they are oval in shape, otherwise they assume the shape of the space available (Fig. 13, 16). The oenocytes are large, but do not approach the size of the nephrocytes. They have large, circular, very strongly staining, single nuclei, surrounded by more weakly staining, homogeneous cytoplasm. Binucleated oenocytes were not observed in *Braula coeca*.

THE REPRODUCTIVE SYSTEM.

Skaife (10) dissected the male and female reproductive organs of *Braula coeca*. He described and illustrated their outlines and external structures. However, he did not notice the bilobing of the testis in the male, neither did he find the accessory glands in the female.

The Male Organs (Fig. 22).—The male reproductive organs consist of a pair of ovoid, bilobed testes. The situation of the testes within the body cavity varies considerably. They lie

among the other viscera, surrounded by fat bodies; sometimes they are found in the dorsal half and sometimes in the ventral half of the body cavity. An individual, sectioned longitudinally in a plane parallel to the ventral surface, may show the right testis cut longitudinally through the center and the left testis not visible. In the same series, a section cut closer to the ventral side may show the left testis cut as a cross section, thus showing that this left testis is standing upright. The testes are found in the region of the second, third and fourth abdominal segment, laterad of the intestines. A slender tube, the vas deferens leads from each testis to a common ejaculatory duct. Slightly caudad from the point of union of the vasa deferentia, a pair of accessory glands joins the ejaculatory duct. The strongly-muscular ejaculatory duct extends caudally, with slight convolutions, from the entrance of the accessory glands to the penis.

The Testes.—The bilobed testes consist of two masses of sex cells. In some series, these cells were observed to be arranged in groups, in others they formed a homogenous cell mass, of uniform cells. Each lobe is surrounded by a tissue-like epithelial layer, (Fig. 22 t) in which no cell walls are visible. The nuclei are large and enclose several strongly-staining chromatin granules. There is another membrane next to the epithelial layer, which encloses the entire testis. This peritoneal membrane takes the stain sparsely. The nuclei are visible in the membrane but are some considerable distance apart. No sign of a cell formation is evident.

The Vas Deferens.—There are only two layers in the vas deferens. The epithelial layer is made up of cone-shaped cells with faintly-staining, finely-granulated cytoplasm. The oval nuclei consist of many small, well-stained chromatin particles. A structureless basement membrane surrounds this epithelial layer.

The Mucous Glands.—The mucous glands, also, consist of only two layers; a glandular epithelium (Fig. 22 mg.), and an enclosing basement membrane. The epithelial cells are cuboid in form and resemble, in their cytoplasmic and nuclear structure, the secretory cells of the salivary glands. The nuclei stain deeply and have a succulent appearance. The surrounding cytoplasm is finely granular and stains deeply, becoming paler as it approaches the lumen. The cell walls are very distinct. A chitinous lining could not be observed in the gland.

The Ejaculatory Duct—The ejaculatory duct consists of seven layers. The first is a chitinous intima which lines the lumen of the duct. The next is an epithelial layer with numerous infoldings (Fig. 22 ed.). Distinct cell walls were not observed in this layer. The nuclei are of moderate size and well stained. The cytoplasm stains weakly. A basement membrane surrounds the epithelium. Three layers of muscle surround the duct and these are lined by a peritoneal membrane. There is first a weak inner layer of circular muscles, followed by a layer of longitudinal muscles and these are surrounded by an extremely strong layer of circular muscles. These muscles are nucleated and stain fairly well.

The Female Reproductive Organs, (Fig. 21).—The female reproductive organs consist essentially of two ovaries, each divided into a pair of ovarioles which are closely allied, and a short oviduct leading from each ovary to a common oviduct, or vagina. The vagina presents a large and strongly muscular structure (Fig. 21 v). A round spermatheca opens through a small duct into the vagina, posterior from the point where the two oviducts unite. There is, also, a pair of short, colleterial glands opening into the vagina. The strongly convoluted vagina extends to the genital opening, where a paired, short, blunt and hairy ovipositor is visible externally. The egg-tubes project along the lateral walls of the abdomen, turning gradually dorsad (Fig. 21), their supporting ligaments being attached to the dorsal wall of the first abdominal segment. Fat bodies, as previously mentioned, surround the egg tubes. The single oviducts lead in a central dorsal direction and unite. The vagina extends gradually ventrad to the vaginal opening, which is on the ventral surface caudad of the eighth sternite.

The Egg Tubes.—An egg tube of *Braula coeca* consists of the following layers: 1. An epithelium; 2. a basement membrane; 3. a peritoneal envelope. The epithelium enfolds the oocytes and is described with the oocytes (Fig. 21). Underlying the epithelium is the basement membrane. The third layer, the peritoneal envelope, is continuous around both tubes, thus enclosing the entire ovary. Attached to the interior surface of the peritoneal membrane are a number of delicate, circular muscle fibres, spaced a short distance apart. The peritoneal envelope appears to be composed of several delicate, almost structureless membranes, with slight signs of nucleation.

A terminal filament, from the distal end of each ovary, attaches to the body-wall, serving as a support.

The germarium contains a mass of cells of varied sizes. The nuclei are indicated by strongly-staining, chromatin granules. There are generally four developing eggs in the vitellarium. The nurse cells present are not confined to the nurse chambers, as in other insects but are enclosed with the developing ova, within the same follicular epithelium. There is not even the slightest constriction of the follicle between the nurse cells and the ova. Ova and nurse cells, together, represent one large oval body. The nurse cells are extremely large and vary in shape, with large dark-staining nuclei, containing several large chromatin bodies. The cell walls are very distinct. The cytoplasm is well stained and heavily granulated. A finely granulated yolk-mass is visible in the lower part of the ova. This increases steadily with the ripening of the egg. As the yolk-mass develops, the size and number of the nurse cells decrease, until they become absorbed in the ripe egg. The epithelial cells of the follicle are cuboid in shape and their size increases with the size of the growing egg. Their plasma is well granulated and their nuclei consist of several small, well-staining chromatin granules.

The Oviduct.—The oviduct consists of an epithelial layer with numerous infoldings. The nuclei are large, circular to oval, and strongly staining. A basement membrane underlies the epithelium; and is surrounded by a very compact layer of longitudinal muscles, which, in turn is surrounded by a heavy layer of circular muscles. This circular layer appears to be made up of several smaller layers. A structureless peritoneal membrane is the last layer surrounding the oviduct.

The Spermatheca.—The interior of the spermatheca is lined by a chitinous intima. Following the intima is the epithelial layer, with large cuboid cells, having moderately sized nuclei, consisting of several small, well-staining chromatin granules. The cell walls are very distinct in the epithelium. A basement membrane surrounds the epithelial layer. The center of the spermatheca is filled with a fluid containing numerous spermatozoa. A section through the reservoir clearly shows tiny whirls. These indicate the movements of the sperms. The layers of the duct leading from the spermatheca to the vagina show the same characteristics as the wall of the spermatheca.

The Accessory Glands.—The small paired accessory glands have a structure very similar to the mucous glands of the male. No sign of an intima is evident. The glandular epithelium consists of a single layer of cells with oval dark-staining nuclei of a succulent appearance. The cytoplasm is roughly granular and strongly staining. The cell walls are distinct. There is a narrow lumen in the center of the glands which opens into the vagina.

The Common Oviduct or Vagina.—A chitinous intima constitutes the first layer of this duct. This intima thickens as the duct approaches the sexual opening and is continuous with the cuticula of the body wall. A strongly folded epithelium, with large distinct cells, is the next layer. These epithelial cells, with the exception of a few around the infolding are cuboid in outline. The nuclei are circular or oval and exhibit many well-stained, chromatin granules. The cytoplasm stains faintly, and has a homogeneous appearance. The epithelium is supported by a basement membrane. A layer of well-developed, longitudinal muscles follows the basement membrane. This layer of longitudinal muscles is surrounded by a multi-layer of circular muscles. A peritoneal membrane encloses all the layers. The muscles on the reproductive organs of the male, as well as of the female, show striation and are distinctly nucleated. The nuclei present a loose arrangement of well staining, chromatin granules.

SUMMARY.

The body wall is covered by a well-chitinized cuticula, penetrated by numerous sense hairs. The pulvilli are of a peculiar form, and function in the same manner as in other *Diptera*.

The nervous system consists of a supra-oesophageal ganglion, fused with the sub-oesophageal ganglion, a thoracic compound ganglion with distinct divisions into three pairs of ganglia, and a single abdominal ganglion.

The alimentary canal consists of an oesophagus; a large crop; a proventriculus, with a proventricular valve; a slightly convoluted mid-intestine; two pairs of Malpighian tubules; and a hind-intestine, with four rectal glands.

The pharyngeal structures reveal a powerful pumping apparatus.

A pair of salivary glands is situated in the prothorax and opens by a common duct, through the labium into the mouth.

Two pairs of thoracic and five pairs of abdominal spiracles are present. There is a pair of longitudinal tracheal trunks, which serve as a center of distribution for incoming air.

The circulatory system is made up of a five-chambered heart with four pairs of ostia; a slender aorta, which forms a thoracic ampulla and opens close to the brain.

The male reproductive organs consist of a pair of bilobed testes; a pair of short vasa deferentia; a pair of accessory glands; and a strongly muscular ejaculatory duct.

The female reproductive organs consist of a pair of ovaries, each ovary being divided into two closely allied ovarian tubes of the meroistic type, the arrangement of the nurse cells in the ova being peculiar to this type; a short muscular oviduct; and a strongly muscular, convoluted vagina. - A single spermatheca and a pair of small colleterial glands open into the vagina.

ACKNOWLEDGMENT.

Acknowledgment is due to Professor Oswald Muck of the Agricultural and Veterinary College of Vienna, for sending 100 specimens of *Braula coeca*, and to the University of Minnesota, particularly to the Division of Entomology and Economic Zoology, for the use of equipment and material to undertake this study. Thanks are due to Dr. W. A. Riley, Dr. M. C. Tanquary and Dr. A. A. Granovsky for examining this paper and offering helpful suggestions. We are also indebted to Mr. Hollis for the photographic work.

LITERATURE CITED.

- (1) Argo, Virgil N. 1927. *Braula coeca* in den Vereinigten Staaten. Archiv fur Bienenkunde, Vol. 8, No. 1, pp. 48-52.
- (2) Arnhart, Ludwig. 1923. Zur Entwicklungsgeschichte der *Braula coeca* Nitzsch. Zool. Anz., Vol. 56, No. 9-10, pp. 193-197, 1 fig.
- (3) Börner, Carl. 1907. *Braula* und *Thaumatoxena*. Zool. Anz., vol. 32, n. 19, pp. 537-549, 9 figs.
- (4) Egger, J. 1853. Beiträge zur bessern Kenntniss der *Braula coeca* Nitzsch. Verhandl. des zool.-bot. Ver zu Wien, Vol. 3, pp. 401-408.
- (5) Handlirsch, A. 1913-25. Schroder's Handbuch der Entomologie, Vol. 3.
- (6) Hewitt, Gordon. 1910. The House Fly. (*Musca domestica*, Linnaeus), Manchester Univ. Press.
- (7) Muggenburg, Friedrich Hans. 1892. Der Russel der Diptera pupipara. Archiv fur Naturgeschichte, vol. 58, No. 1, pp. 287-332, pls. 15, 16.
- (8) Phillips, E. F. 1925. The Bee-Louse, *Braula coeca*, in the United States. U. S. Dept. of Agric., Dept. Circular 334.
- (9) Reamur. 1740. Memoires pour servir a l'histoire des Insectes, vol. 5. Paris.
- (10) Skalfe, S. H. 1921. On *Braula coeca* Nitzsch, a dipterous parasite of the honeybee. Trans. Roy. Soc. S. Africa, Vol. 10, Pt. 1, pp. 41-48; 11 figs.

EXPLANATION OF PLATES.

Figs. 5, 7, 17—Schematic drawings.

Figs. 2, 3, 4, 8, 9, 12, 14—Half schematic drawings.

Figs. 6, 10, 11, 13, 15, 16, 18, 19, 20—Camera lucida drawings.

Figs. 21, 22—Outline of Reproductive Organs, schematic. Sections through parts indicated, camera lucida drawings.

PLATE I.

Fig. 1. Sensory hair.

Fig. 2. Muscle attachment to Body-wall.

Fig. 3. Muscle attachment to Endothorax.

Fig. 4. Section of Crop-wall.

Fig. 5. Longitudinal median section of *Braula coeca*.

Fig. 6. Malpighian Tubule.

PLATE II.

Fig. 7. Nervous System.

Fig. 8. Section of Mid-intestinal Wall.

Fig. 9. Section of Hind-intestinal Wall.

Fig. 10. Pulvillus.

Fig. 11. Salivary Gland.

Fig. 12. Abdominal Spiracle.

Fig. 13. Oenocytes.

Fig. 14. Meso-thoracic Spiracle.

PLATE III.

Fig. 15. Fat Bodies.

Fig. 16. Oenocytes in Fat Body.

Fig. 17. Dorsal Vessel.

Fig. 18. Cross-section of the heart.

Fig. 19. Nephrocytes.

Fig. 20. Trachea.

PLATE IV.

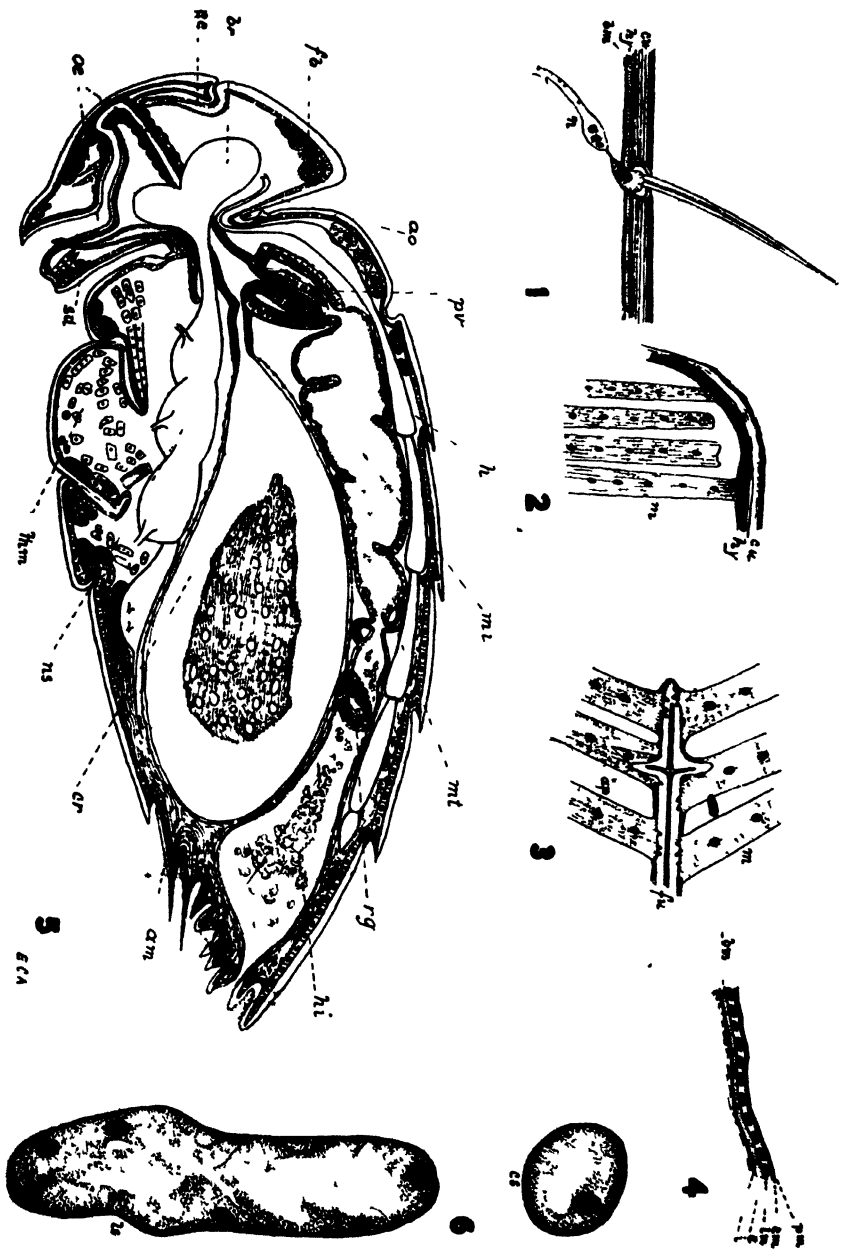
Fig. 21. Female Reproductive Organs.

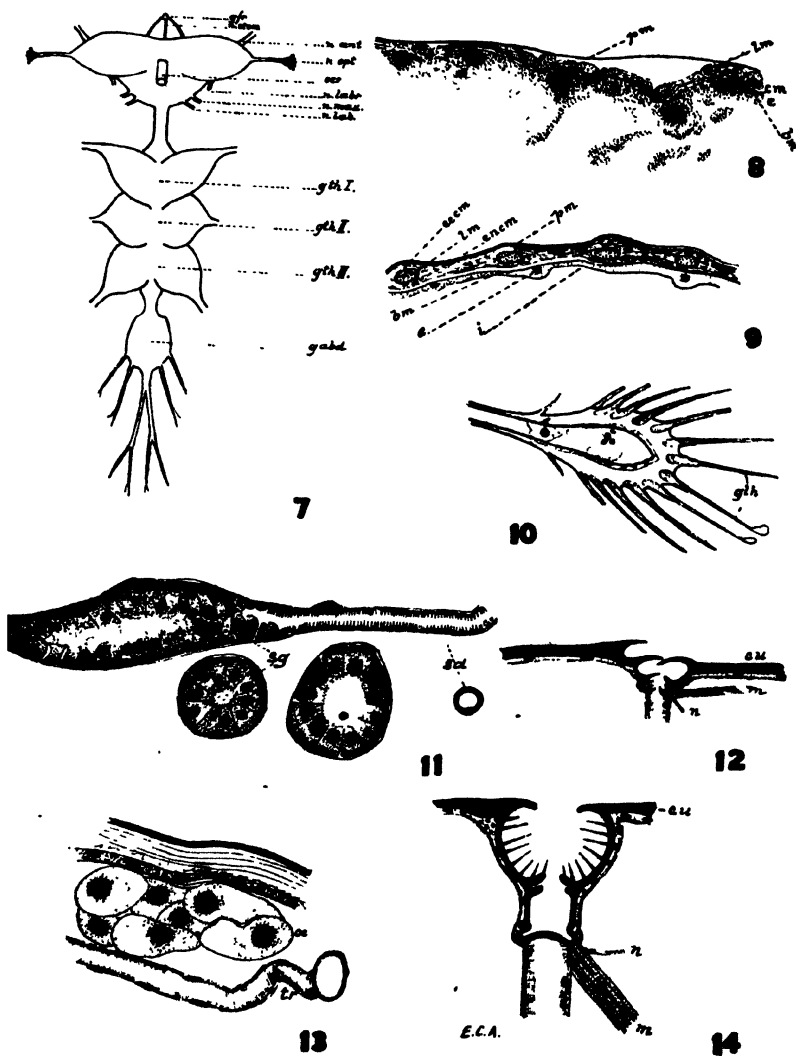
Fig. 22. Male Reproductive Organs.

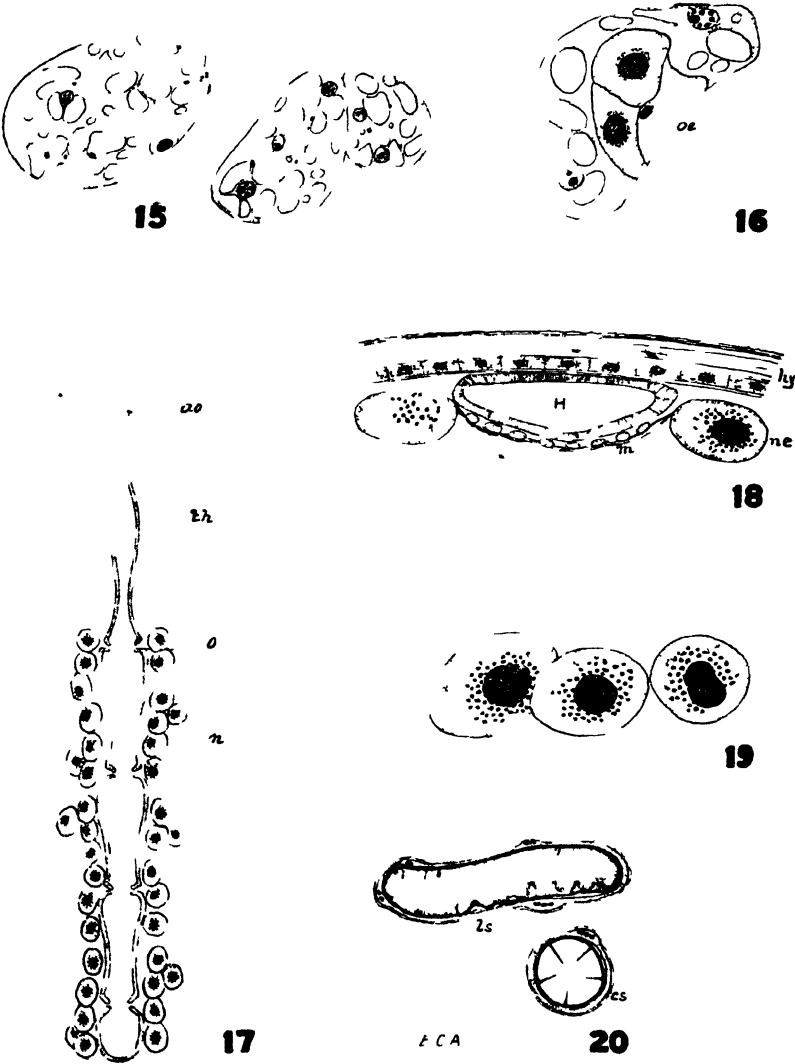
ABBREVIATIONS.

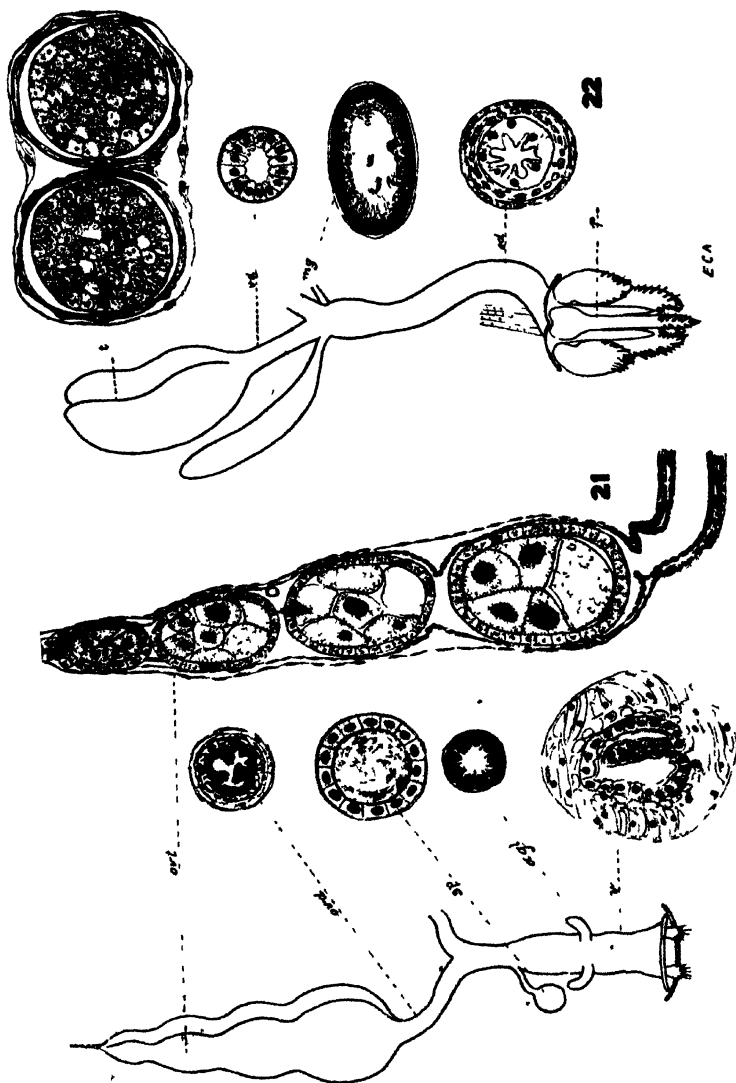
agl—accessory gland.
am—abdominal muscles.
ao—aorta.
ap—apodeme.
bm—basement membrane.
br—brain.
c—cuticula.
cc—ptilinum.
cm—circular muscle.
cs—cross section.
cr—crop.
cu—cuticula.
e—epithelium.
eccm—ectal circular muscle.
ed—ejaculatory duct.
encm—ental circular muscle.
fb—fat body.
fu—furca.
g abd—abdominal ganglion.
g fr—frontal ganglion.
g th—thoracic ganglion.
h, H—heart.
hi—hind-intestine.
hy—hypodermis.
i—intima.
lm—longitudinal muscle.
ls—longitudinal section.
m—muscle.
mg—mucous gland.

mi—mid-intestine.
mt—Malpighian tubule.
n—nerve.
ne—nephrocyte.
n ant—antennal nerve.
n lab—labial nerve.
n labr—labral nerve.
n max—maxillary nerve.
n opt—optic nerve.
ns—nervous system.
n-stomo—gastric nerve.
o—ostia.
oe—oenocyte.
oes—oesophagus.
ovd—oviduct.
ovt—ovarian tube.
p—penis.
pm—peritonal membrane.
pv—proventriculus.
rg—rectal gland.
sd—salivary duct.
sg—salivary gland.
sp—spermateca.
t—testis.
th—thoracic ampulla.
thm—thoracic muscles.
tr—trachea.
v—vagina.
vd—vasa deferentia.









TWO NEW MALLOPHAGA FROM TWO CLOSELY RELATED SHOREBIRDS.

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There are described herein two new species of Mallophaga collected from two species of shorebirds: Lesser yellowlegs, *Totanus flavipes* (Gmelin) and greater yellowlegs, *Totanus melanoleucus* (Gmelin), both common during migrations in the United States. These two sandpipers (Order Charadriiformes, Family Scolopacidae) are almost indistinguishable in coloration but the greater yellowlegs is about one-third larger in size than the lesser yellowlegs. The two new species of Mallophaga are easily separated by the different male genitalia; in other characters they closely resemble each other; the larger louse is found on the larger bird.

Degeeriella falcigera, new species.

DESCRIPTION OF MALE.—*Head* of Philopterus type, rather elongate conical in shape, being one and three-fifths times as long as broad and twice as broad across the temples as at anterior border of clypeus. Clypeus with a slightly convex and expanded hyaline margin; signatural plate somewhat shield-shaped; distinct clypeal suture; trabeculae distinct and uncolored, almost as long as first antennal segment, but not moveable. Antennae with second segment longest, fifth longer than third or fourth, which are equal, pale with fifth segment darkest. Eyes clear, with a long and a short ocular seta. Three short lateral setae on clypeus; two before trabeculae; two long and two short setae on rounded temples. Posterior edge of head slightly concave and bare. Color golden brown; with dark brown antennal bands interrupted at clypeal suture; temples margined with dark brown; mandibles, esophageal sclerite, narrow occipital bands, and triangular gular signature medium brown.

Thorax about two-thirds as long as head, golden brown with dark brown lateral margins. Prothorax trapezoidal, sides slightly diverging, with a short seta in latero-posterior angle. Pterothorax as wide as head and one and two-thirds times as long as prothorax, trapezoidal with diverging and slightly concave sides, and posterior edge slightly angled. A group of three pustulated setae in latero-posterior rounded angle and two pustulated setae nearer the middle on the posterior border. Legs all about equal in length, with femora rather robust, coxae situated near lateral edges of thorax.

Abdomen of nine segments, elongate, golden brown with dark brown lateral margins, each segment with somewhat indistinct darker transverse markings, sutures lighter, segments 2 to 5 each having a narrow median uncolored line extending from the suture to middle of each segment. First segment short, slightly converging posteriorly; segments 2 to 6 about equal in length; fourth segment widest; segments 7, 8, and 9 rapidly narrowing posteriorly; segment 9 half the width of segment 6 and broadly rounded with about twelve small setæ projecting posteriorly. Pleurites long, pointed, projecting into preceding segment, and dark brown; the dark brown color extending toward the center in anterior half of segments, the spiracles on segments 2 to 7 in lateral light brown area just posterior to middle of segment. On dorsal surface segment 1 has two setæ on posterior border; segment 2 has four setæ; segments 3 to 5 have six setæ. Some setæ in lateral angles and on ventral surface. Genitalia very distinctive. Basal plate consisting of two rods extending to the fifth abdominal segment. Parameres long, curved, and pointed; endomeres with peculiar sharp lateral projection and divided into a dorsal and a ventral projection at their anterior end. (Fig. 1).

DESCRIPTION OF FEMALE.—The same as the male except that it is somewhat broader and longer; the ninth abdominal segment is bilobed; and the eighth segment has a number of setæ on the lateral and posterior margins.

AVERAGE MEASUREMENTS IN MILLIMETERS.

	MALE		FEMALE	
	Length	Width	Length	Width
Head.....	0.404	0.253	0.423	0.267
Prothorax.....	.106	.188	.110	.195
Pterothorax.....	.174	.257	.195	.268
Abdomen.....	1.000	.363	1.146	.392
Total.....	1.684		1.874	

Type Host: Lesser yellowlegs, *Totanus flavipes* (Gmelin).

Type locality: Sandusky, Ohio.

Type (holotype and allotype): Cat. No. 43514 U. S. N. M.

The holotype male and allotype female were collected from the type host at the type locality on September 12, 1925, by myself. The paratypes are in the collection of the Bureau of Entomology and in my personal collection.

Described from seventy specimens all collected from lesser yellowlegs as follows: Two males and three females from Washington D. C., September 24, 1919, by E. A. Chapin

(in National Museum collection); four males and three females from Columbus, Ohio, May 6, 1925, by myself; four males and six females from North Eastham, Mass., September 10, 1925, by O. L. Austin, Jr.; eleven males and fifteen females from Sandusky, Ohio, September 12, 1925, by myself; one female from Sandusky, Ohio, October 14, 1925, by M. B. Trautman; one female from Columbus, Ohio, April 13, 1926, by R. W. Franks; one female from Columbus, Ohio, April 30,

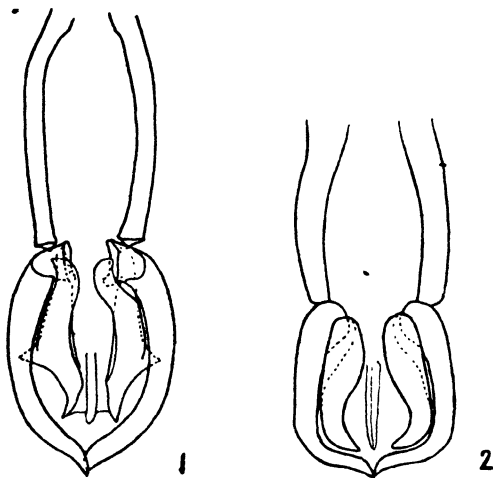


Fig. 1. *D. falcigera* n. sp., male genitalia, $\times 200$.

Fig. 2. *D. austini* n. sp., male genitalia, $\times 200$.

1926, by myself; one male and one female from Chincoteague, Virginia, March 26, 1927, by myself; one male and three females from Munuscong Bay, Michigan, August 19, 1927, by C. F. Walker; and eight males and five females from South Caicos Island, Bahama Islands, July 29, 1930, by myself (Bish. No. 15186). Dr. E. A. Chapin, of the National Museum, suggested the name *falcigera* for this species.

Degeeriella austini, new species.

DESCRIPTION OF MALE.—Broader and longer than *D. falcigera*, with latero-posterior angles of pterothorax having two long and three shorter setae, and three setae nearer the middle along the posterior border; the pleurites more narrow. Genitalia distinctive. The two rods of the basal plate are shorter than those of *D. falcigera*, extending

into the sixth abdominal segment; the parameres and endomeres are sharply elbowed and pointed; the endomeres are folded at their anterior end. (Fig. 2).

DESCRIPTION OF FEMALE.—Almost identical with the female of *D. falcigera*, but somewhat broader and longer.

AVERAGE MEASUREMENTS IN MILLIMETERS.

	MALE		FEMALE	
	Length	Width	Length	Width
Head.....	0.493	0.316	0.501	0.321
Prothorax.....	.126	.240	.124	.240
Pterothorax.....	.210	.320	.217	.319
Abdomen.....	1.118	.468	1.250	.479
Total.....	1.947		2.092	

Type host: Greater yellowlegs, *Totanus melanoleucus* (Gmelin).

Type locality: Windy Tickle, Labrador.

Type (holotype and allotype): Cat. No. 43515 U. S. N. M.

The holotype male and allotype female were collected from the type host at the type locality on August 23, 1926, by O. L. Austin, Jr. The paratypes are in the collection of the Bureau of Entomology and in my personal collection.

Described from nine specimens, all collected from greater yellowlegs by O. L. Austin, Jr., as follows: Three females from North Eastham, Mass., September 14, 1925; and five males and one female from Windy Tickle, Labrador, August 23, 1926. Named in honor of Dr. O. L. Austin, Jr., who has sent the writer many interesting Mallophaga from birds he has collected.

D. falcigera and *D. austini* are not very close to any described species of Mallophaga. *D. boephila* (Kellogg), described from a killdeer, *Oxyechus vociferus* (Linn.), is somewhat similar but is much narrower and easily distinguished by the markings and genitalia.

THE GENUS DRYLIX IN NORTH AMERICA, (HOMOPTERA, CICADELLIDÆ).*

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In his study of the North American Species of Euscelis and Allied Genera, Slesman records five species in the genus Drylix, one species of which, *D. truncatus*, he described from male specimens. The writer had before him, awaiting description when this paper appeared, both males and females of this species and specimens of two additional species in the genus. In this paper the allotype of *D. truncatus* and these two additional species are described, and the key to the genus modified to contain the seven species now found in the genus in North America.

KEY TO SPECIES OF DRYLIX.

1. Vertex slightly but definitely produced..... 2
Vertex not definitely produced, nearly parallel margined..... 3
2. Species usually under 5 mm.; male plates moderately long... *striolus* Fall
Species usually over 5 mm.; male plates very long *utahus* n. sp.
3. Male plates not caliper like..... 4
Male plates caliper like..... 6
4. Male plates truncate apically..... *truncatus* Slesman
Male plates rounded apically..... 5
5. Male plates shorter than valve..... *medianus* n. sp.
Male plates longer than valve..... *parallelus* (Van Duzee)
6. Male plates long, apices narrowly produced *divaricatus* Sanders and DeLong
Male plates short, apices bluntly produced *uncolus* Ball

Drylix truncatus Slesman.

(Figs. 3, 3a, 3b.)

The male only of this species was described by Slesman. Following is the description of the female.

Allied to *parallelus* but broader and darker and with distinct genitalia. Length 5.5 mm.

Head distinctly wider than pronotum; vertex parallel margined, three times as wide as long. Pronotum about twice as long as vertex, nearly three times as wide as long. Elytra greatly exceeding abdomen.

Color: Well colored specimens strikingly black and yellow. Vertex mostly black, with narrow yellow line between ocelli and wider yellow band on posterior margin. Pronotum with anterior margin narrowly

*Contribution from the Department of Entomology, University of Kansas.

black and with broad black band on posterior half entirely surrounded by yellow. Scutellum yellow, disc and basal angles brokenly black. Elytra smoky to black, nervures mostly yellow. Face mostly black; arcs and median line on front, sides of clypeus, spots on loræ and margins of genæ, yellow. Legs mostly black, marked with yellow. Underside mostly black.

Genitalia: Female last ventral segment about as long as preceding, median third of posterior margin shallowly concave, outer thirds still more shallowly concave and separated from middle third by a sharp and distinct point.

A specimen from Atherton, Mo., taken by C. F. Adams on June 11, 1922, is designated as the *Allotype* of this species and is deposited in the Snow Entomological Collection. Other specimens are at hand from Cherokee and Douglas counties, Kansas; Atherton, Mo.; and Arlington, N. J.

***Drylix medianus* n. sp.**

(Figs. 2, 2a, 2b.)

Allied to *parallelus* but more slender and elongate and with male plates shorter. Length 5.25–5.5 mm.

Head distinctly wider than prothorax; vertex very slightly longer at the middle than next the eye, three times as wide as long. Pronotum about twice as long as vertex, a little over twice as wide as long, anterior margin rather strongly convex. Elytra greatly exceeding abdomen.

Color: Well colored specimens dark brown and yellow. Vertex with narrow yellow line between light ocelli, posterior margin rather broadly yellow, the rest black. Pronotum mostly yellow, anterior margin narrowly dark brown and most of disc brokenly dark brown. Scutellum yellow, basal angles and portion of disc dark. Elytra mostly smoky to dark brown, nervures light yellow. Front black except for yellow arcs; sutures of loræ and clypeus and middle line of latter, dark; rest of face yellow. Legs yellow, marked with brown. Underside mostly dark, margins of segments, plates, and pygofer light.

Genitalia: Female last ventral segment half longer than preceding; posterior margin with rounded median notch extending about one-third of distance to base and with distinct obtuse angles on either side of notch. Male valve large, bluntly angled; plates slightly shorter than valve, margins broadly convex, rather spiny.

Holotype, male, Grand Marais, Minn., Aug. 11, 1922, taken by H. H. Knight. *Allotype*, female, and a male and female *paratype*, same data.

Holotype and female paratype deposited in Snow Entomological Collection. Allotype and male paratype in Dr. Knight's collection.

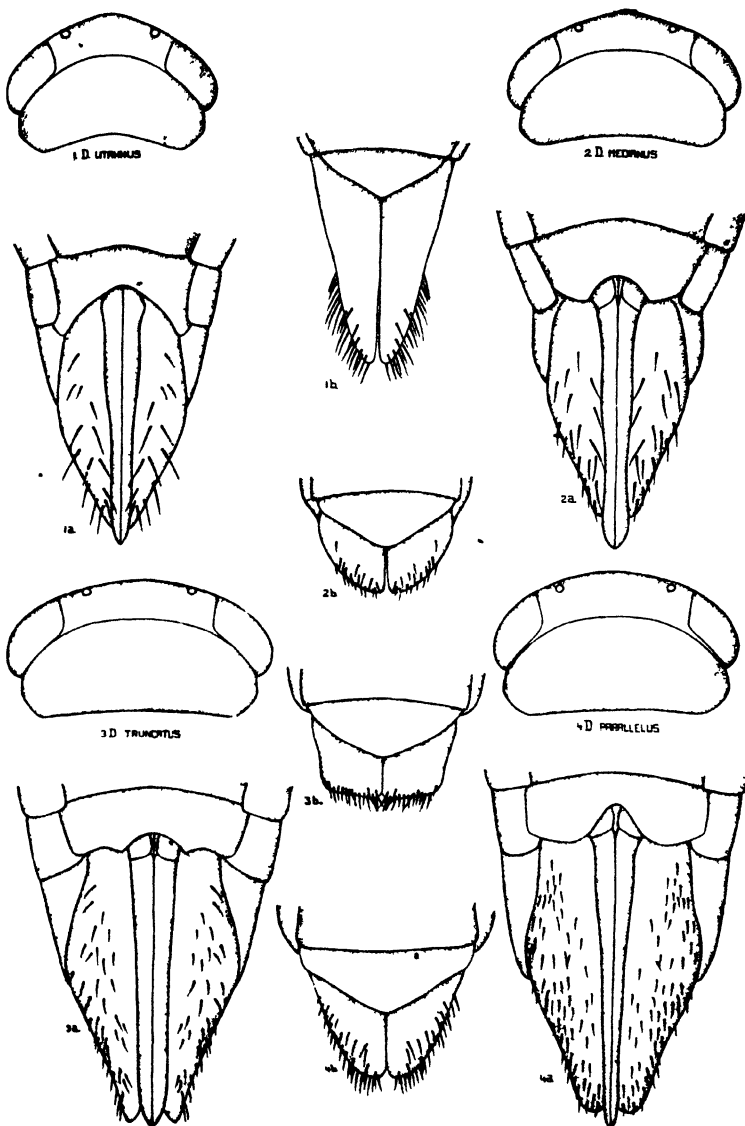


Fig. 1. *Drylix utahnus* n. sp.
Fig. 1a. *Drylix utahnus*, female genitalia.
Fig. 1b. *Drylix utahnus*, male genitalia.
Fig. 2. *Drylix medianus* n. sp.
Fig. 2a. *Drylix medianus*, female genitalia.
Fig. 2b. *Drylix medianus*, male genitalia.
Fig. 3. *Drylix truncatus* Slesman.
Fig. 3a. *Drylix truncatus*, female genitalia.
Fig. 3b. *Drylix truncatus*, male genitalia.
Fig. 4. *Drylix parallelus* (Van Duzee).
Fig. 4a. *Drylix parallelus*, female genitalia.
Fig. 4b. *Drylix parallelus*, male genitalia.

This species has male genitalia midway between *truncatus* and *parallelus*. The plates are shorter than in the latter but not truncate as in the former. The female segment has a shallower notch than in *parallelus* and the outer thirds of the posterior margin are not concave as in *truncatus*. The genitalia of all three species are figured for comparison. In general appearance also this species is more slender than the other two to which it is closely related.

The writer is indebted to Dr. H. H. Knight for all four specimens available.

***Drylix utahnus* n. sp.**

(Figs. 1, 1a, 1b.)

Closely allied to *striolus* but larger and with male plates much longer. Length 5-5.5 mm.

Vertex but slightly produced at the middle, slightly over twice as wide as long. Pronotum about twice as long as vertex, anterior margin strongly convex. Elytra very long, greatly exceeding abdomen.

Color: General color dirty or brownish yellow. Vertex yellow with definite black band caudad of ocelli separating yellow basal portion from narrow yellow line between ocelli. Pronotum dirty yellow with signs of brownish mottling on anterior third. Scutellum entirely yellow or with few brown spots. Elytra smoky yellow, nervures paler, cells smoky to brown. Face yellow with arcs of front and sutures black. Legs yellow, marked with brown. Underside varying black and yellow.

Genitalia: Female last ventral segment half longer than preceding, posterior margin broadly concave about half way to base. Male valve small, triangular; plates triangular and very long, their acute apices greatly exceeding pygofer.

Holotype, female, Richfield, Utah, July 15, 1929. Light trap. Deposited in United States National Museum.

Allotype, male, same data. Deposited in Snow Entomological Collection.

Both specimens were made available for study through the courtesy of Mr. E. W. Davis.

SEVEN NEW SOUTHERN SPECIES OF THE MAYFLY GENUS *HEXAGENIA*, WITH NOTES ON THE GENUS.*

JAY R. TRAVER.

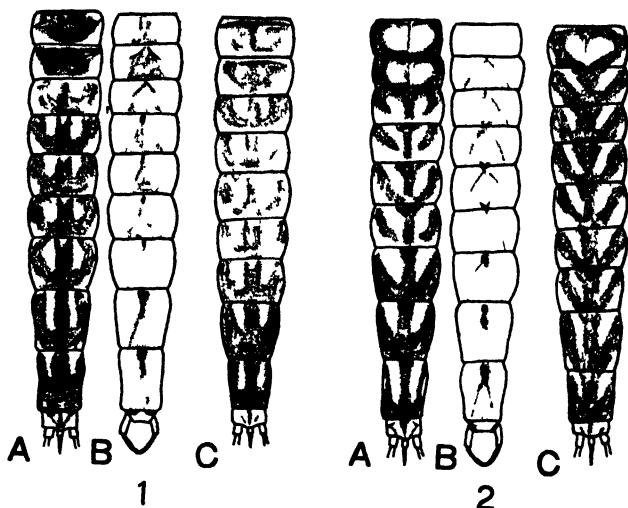
From material in the collection at Cornell University, and from other material collected by Prof. J. G. Needham from West Virginia, and by Miss L. E. Brett and the author from North Carolina, seven new southern species of the genus *Hexagenia* are herein described. An attempt has been made to formulate keys to the known species of *Hexagenia* in the United States and Canada, for both males and females (in so far as the latter are known). Likewise a tabulation of some of the characters of the males of each species has been prepared, in the hope that this table may supplement the key, and aid in identification. Color patterns of both males and females of the new species are given, to supplement those of several previously described species published by other authors. Notes on several species of *Hexagenia* nymphs are likewise presented.

In descriptions of the wings of the various species, the term "costal margin" is used to include both the costal and sub-costal cells. Where reference is made to dark spots in the wing, such spots are formed, as in the species *H. bilineata*, by some of the cross veins being margined or bordered on each side with black or very dark purple.

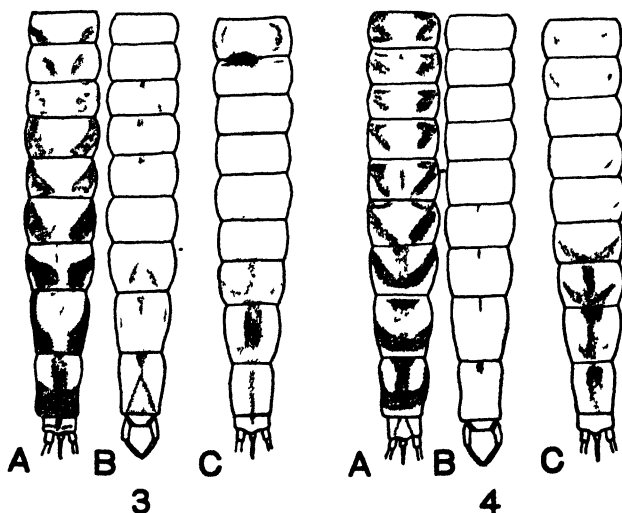
COLOR PATTERNS.

Typical color patterns of the abdomens of the males of several species of the genus *Hexagenia* have been figured by previous writers. Thus Ulmer, 1921, (p. 237, Figs. 6 and 7) has figured *H. bilineata* and *H. limbata*; and McDunnough, 1927, (p. 117, Fig. 1) has shown *H. bilineata*, *H. atrocaudata*, *H. rigida*, *H. affliata*, and *H. viridescens*. In the present article are given typical patterns for the seven new species herein described. The first figure of each group represents the dorsal aspect of the male abdomen; the second, the ventral aspect of the same; the third (not known for *H. rosacea*) shows the dorsal aspect of the abdomen of the female. (See text Figures 1-7.)

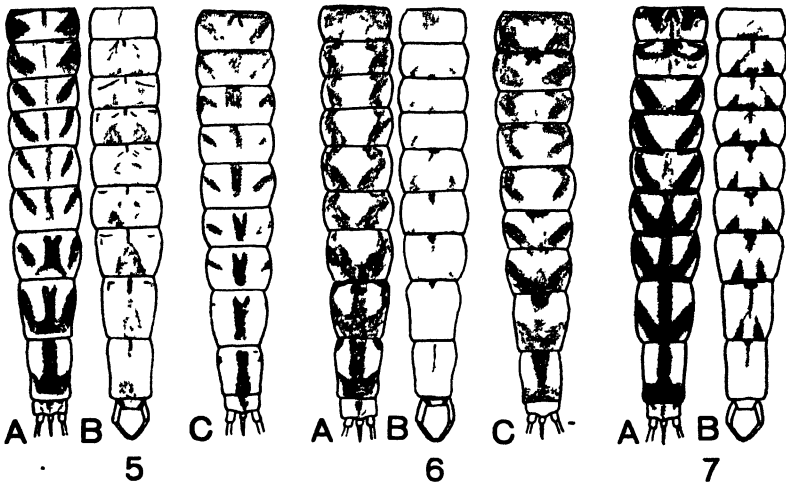
*Contributions from the Limnological Laboratory of Cornell University.



1. *Hexagenia mingo* A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
2. *Hexagenia orlando*. A and B, dorsal and ventral abdominal markings of male, C, dorsal of female.



3. *Hexagenia elegans* A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
4. *Hexagenia carolina*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.



5. *Hexagenia weewa*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
 6. *Hexagenia marilandica*. A and B, dorsal and ventral abdominal markings of male; C, dorsal of female.
 7. *Hexagenia rosacea*. A and B, dorsal and ventral abdominal markings of male.

TYPES OF GENITALIA.

In the tabulation of characters of *Hexagenia* males, it will be noted that the types of genitalia are indicated by Roman numerals I to VI, inclusive. These are listed in the order in which they have been described and figured. A brief résumé of these types follows.

I. *Limbata type* First figured by Eaton, 1883-88 (Pl. VII, Fig. 11c); next by Needham, 1920, (Pl. LXXXI, Fig. 63), under the name *bilineata*, form *variabilis*; and most recently by Ulmer, 1921 (p. 236, Fig. 4). The penes are hook-like and bent forwards, in characteristic position approaching or even overlapping one another at the tips. Ulmer indicates (p. 238) that the end-joints of the forceps limbs in this form are broad. This statement does not hold good, however, for all the species examined by the writer which have the *limbata* type of genitalia. Thus, *H. venusta* has typical *limbata* type penes, but the end-joints of the forceps limbs are as slender as in typical *H. bilineata*. This type of genitalia is found in a number of species, (Fig. 19).

II. *Bilineata type*. Figured by Needham, 1920 (Pl. LXXXI, Fig. 62) as *bilineata*, form *falcata*; and by Ulmer, 1921 (p. 236, Fig. 5). In this form the penes are elongated at the tip into bill-like structures which often overlap, as the penes characteristically approach and touch one another. This form of genitalia seems confined to the one

species *H. bilineata* Say. The end-joints of the forceps limbs, as indicated by Ulmer, are characteristically thin and slender, (Fig. 14).

III. *Recurvata* type. Figured by Morgan, 1913 (p. 395, Fig. 3). The penes are recurved at the tip, and do not approach one another. The first joint of the forceps limb is remarkably short and stout, the second unusually long, the two end joints rather short and stout. This type seems confined to the single species *H. recurvata* Morgan, (Fig. 18).

IV. *Rigida* type. First figured by Eaton, 1883-88, (Pl. VII, Fig. 11b 2) as *bilineata*; by Needham, 1920 (Pl. LXXXI, Figs. 61 and 65) as *bilineata* and *falcata*; later figured and named by McDunnough, 1924 (Pl. I, Fig. 3). The penes here are long and straight, not approaching one another. The forceps limbs are stout, as are also the end-joints. This type may be confined to the species *H. rigida* McD., although several specimens in the Cornell University collection, which do not exhibit characteristic markings of this species, do possess the *rigida* type of genitalia. (Fig. 16).

V. *Atrocaudata* type. Figured by Needham, 1920 (Pl. LXXXI, Fig. 64) as *bilineata*, form *munda*; and figured and named by McDunnough, 1924 (Pl. I, Fig. 2). The penes are short and broad, bluntly pointed, and do not approach one another closely. The forceps limbs are quite thick-set; the end-joints, especially the third joint (first of the end-joints) are unusually long and stout. This type seems confined to the single species *H. atrocaudata* McD. (Fig. 12).

VI. *Carolina* type. This type somewhat resembles the *limbata* type. In a few cases the two seem to intergrade, so that it is difficult, as in the case of the new species *H. marilandica*, to state which type is present. In the typical form, however, as shown well by the other new species here described, the penes are but slightly bent, not showing the characteristic hook of *limbata*, and either stand erect, bend slightly outward, or rarely approach one another slightly. The tips always bend inward, not outward. The forceps limbs may be stout, with very long second joint, and the third joint also unusually long and stout, as in *H. weewa*, and to a lesser degree in *H. carolina*. Or they may be more slender, and the end-joints be unusually short, as in *H. elegans*. Several of the southern species show this type of genitalia. (Figs. 10, 11, 13, 17, 20, 22).

Hexagenia elegans, n. sp.

A very small species, Hind wings of male bordered with purplish brown, markings of abdomen predominantly purplish red.

	MEASUREMENTS.			
	Body	Tails	Foreleg	Fore-wing
Male subimago..... (3 specimens)	13½-15	14-17	5	11-12
Female subimago..... (2 specimens)	16 -17	12-12½	5-6	12-14
Male imago..... (20 specimens)	12 -17	30-38	8-10	10½-12
Female imago..... (20 specimens)	14 -19	18-27	5-7	12-18

MALE IMAGO.

Head: Upper portion of compound eye golden tan. Vertex cream-colored, occiput flesh-colored. Ocelli ringed at base with black, above this with purplish rose. Dorsal aspect of frontal carina purplish. Second antennal joint and base of filament light rose. Diameter of eye is to space between the eyes approximately as 1:1.

Thorax: Prothorax flesh-colored, with two longitudinal dorsal mahogany-red stripes. Meso- and metanotum and portion of pleurum of metathorax creamy white. Mesopleurum light red-brown. Prosternum white with dark purple spot posteriorly. Anterior of mesosternum and all of metasternum dark mahogany-red. Posterior of mesosternum lighter shade of same.

Legs: Femur and tibia of foreleg dark rose-red; tarsus purplish-brown except proximal half of second, third and fourth joints, which are white. Other legs white. Claws, distal joint of tarsus except at base, distal border at fourth tarsal joint, and faint border at other tarsal joinings, purplish brown.

Wings: Very iridescent. Fore wing with dark brown costal border, to vein R. Outer margin of hind wing purplish-brown. Main longitudinal veins of fore wing, of costal area of hind wing, and cross veins of both wings, purplish black. In both wings, prominent purplish-black spots.

Abdomen: Ground color white, faintly flushed with pink ventrally on segments 1-6; definitely yellowish on 7-10. Dorsal markings consist of reddish-brown longitudinal median stripe on 7-10, continued forward as a faint grey line on 1-6, very narrow on 1-3. On each side of tergites 1-9, a rose-brown oblique mark, its base on or near the posterior margin, extends laterally to the pleural fold. On tergites 1-4 it has the shape of a parallelogram, on 5-9 wedge-shaped. This mark varies in color on different specimens from rose or red-brown to greyed lavender. Tergite 10 with brown oblique lateral marks. Sternite 9 with a rose-colored triangle, its base on the posterior margin, its apex not attaining the anterior margin. Other sternites with rose lateral stripes from posterior border half-way to pleural fold, extending obliquely forward toward mid-ventral line. In light-colored specimens these stripes do not attain the median line; in darker specimens, they reach it near the anterior border.

Genitalia: Very slender, of the *carolina* type. Basal joint of forceps limb, distal one-third on the second joint, and its ventral ridge, purplish brown (in light specimens, grey). The two short distal joints, which are remarkably small, light brown to yellowish. Forceps base purplish brown, a rose spot on each side. Penes with ventral purplish brown stripe. (Fig. 11).

Tails: Distal portion of each joint dark brown, with darker ring at joining. Proximal portion of each greyish white. In some joints the dark brown occupies all but a narrow white proximal ring.

FEMALE IMAGO.

Entire body creamy white. Ocelli ringed with black, rose spot on each side at base. Grey-purple stripe on pronotum, becoming golden yellow on mesonotum. Yellowish brown oblique mark along main lateral suture of mesopleurum, to base of middle leg.

Legs: Foreleg with rose band at base of femur and near distal end of tibia. Claws, distal two-thirds of last tarsal joint, and all joinings except base of femur, purple-brown. Other legs with claws and last tarsal joints similar, but no color at joinings save those of the third and fourth tarsal segments.

Wings tinged with greenish yellow; longitudinal veins yellow, cross veins purple black. Neither wing with brown or purple margin.

Abdomen: Dorsally with longitudinal dark-grey median stripe, as in male. Tergites 1 and 2, in some specimens, with large central grey-black patch; 1 margined posteriorly with black. Grey-brown arms extend forward for a short distance from each side of median brown band, at posterior margin.

Tails: Yellowish white, ringed indistinctly with grey at joinings. In proximal portion, every third or fourth joining with blackish-purple ring.

Holotype: ♂, imago. Taken from the Chowan River, near Winton, Hertford Co., N. C. by Miss L. E. Brett. Second week of August, 1930. No. 917.1 in C. U. collection.

Allotype: ♀, imago. Same. No. 917.2 in C. U. collection.

Paratypes: 12 ♂s and 8 ♀s, all imagos. Same place and collector. Second and third weeks of August, 1930. No. 917.3-.22, in C. U. collection.

Miss L. E. Brett gives the following account of the collecting of *Hexagenia elegans*.

"These *Hexagenias* were captured in northeastern North Carolina at Tuscarora Beach, on the Chowan River, about three miles east of the little town of Winton and eight miles from the point where the Meherrin and the Nottaway Rivers unite to form the Chowan. This location is approximately seventy miles from the sea.

At the point where the *Hexagenias* were caught the river is something like 35 to 40 feet deep and 500 feet or more in width. On the west bank is a wide sandy beach and on the east a swamp extending a mile out from the river.

The *Hexagenias* were seen in great numbers between eight and ten o'clock in the evening during the latter part of July and most of August. The writer first saw them sitting on the electric light wires over the bathing beach. Upon investigation they were discovered on the window of the merry-go-round ticket office and even swarming on the canvas at the top of the merry-go-round, which was some 150 yards from the water. They took possession of the dance pavilion and became a nuisance at the soda shop. Some were even found

sitting on passersby at the beach. They literally took the place 'by storm.' The adults were seen as early as 7:30 o'clock dipping in the shallow waters.

When this discovery was made, cages were secured and the mayflies were picked by hand from every object in sight, put in the cages and left to finish transformation. Many of them did transform, while others died in the process. Then a search for the nymphs was made. But though the sandy silt was dug up out as far as a person could wade, no trace of a single nymph could be found."

Hexagenia mingo, n. sp.

A medium-sized species. Hind wing of male with or without purplish outer margin. Dorsal aspect of abdomen with reddish brown markings.

MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male subimago..... (1 specimen)	17½	19	5	15
Female subimago..... (1 specimen)	25	?	6	20
Male imago..... (2 specimens)	17½	32-36	12	14½
Female imago..... (1 specimen)	23	29	9	21

MALE IMAGO.

Head: Light tan. Vertex with cream yellow markings. Black ring at base of ocelli, and space between them black. Dorsal aspect of median carina dark grey. Occiput with purplish red marks. Upper part of compound eye cream to light tan. Second antennal joint and filament brown. Compound eye is to space between eyes approximately as 1: 0.75.

Thorax: Pronotum light tan, with rather wide dark reddish brown stripes, extending to wing bases. Mesonotum light tan with dark brown markings. Anterior of mesopleurum and metanotum light brown. Other pleura cream-white. Anterior third of prosternum cream-white, other parts very dark reddish brown. Mesosternum light red brown in center, bordered by dark brown. Metasternum dark brown.

Legs: Coxa and trochanter of foreleg brown. Femur and tibia mahogany red-brown, darker at joinings. Tarsus dull yellowish brown, darker at joinings and with darker streaks. Other legs canary yellow. Claws, fifth tarsal joint and joinings of all but first tarsal joint purplish brown.

Wings: Costal margin of fore wing reddish brown except at apex and next to vein C in basal portion, which regions are light tan. Longitudinal and cross veins of both wings dark purplish. Several cross veins in each wing margined with purple. Hind wing with definite purplish-brown outer margin in some specimens, but lacking in others.

Abdomen: Cream white or faintly pinkish ground color, yellow on 8-10. Rather wide median longitudinal stripe on dorsum, dark reddish brown; wider at posterior margin of each tergite. On 3-9, wide reddish brown bands arise from median stripe at posterior margin, extend outward to pleural fold just below the anterior margin, then upward and inward to meet the anterior margin a short distance from median stripe. Each side of each tergite is thus largely reddish brown, the ground color showing slightly at anterior lateral angle, in a large triangle at posterior lateral angle, and a triangular to round spot on each side of center, enclosed except anteriorly near median line. Tergite 10 yellow with greyish brown stripe, and two lateral stripes ending in dark spots near anterior lateral angle. Ventrally, light reddish brown triangles, their bases on the posterior margin, extend forward to the anterior margin on sternites 1-8. Wider basally on 1-6, narrow on 7 and 8. Each triangle becomes darker in color over ganglionic area, and on posterior sternites a dark mark extends on median line almost the length of the segment. In center of each sternite near median line, a clear round spot. Sternites 9 and 10 yellow, with reddish median line, no lateral marks.

Tails: Rudimentary median tail with dark band at each joining, dorsally. Joints of outer tails light yellow-brown in basal half, darker brown distally, joinings still darker. Near distal end of seta, joints brown except for yellow proximal ring.

Genitalia: Almost intermediate between *carolina* and *limbata* types, but considered here as of the *limbata* type. Forceps base yellow with two purplish brown spots at anterior margin, opposite forceps limbs. Forceps limbs yellow; basal joint streaked ventrally with purplish brown. Distal end of second joint and the short end joints same color. Penes with purplish brown streak on distal half, ventrally. (Fig. 21).

FEMALE IMAGO.

General color of body creamy yellow. **Head** bright sulphur yellow. Vertex cream-colored with two broad purplish-black oblique lateral bands from posterior outer margin toward center. Median carina, bases of ocelli and space between them, black. Antenna as in male.

Thorax: Pronotum greyish white with purplish grey longitudinal stripes. Mesonotum cream, with faint greyish marks near center, a purplish brown median mark on posterior half, its posterior extension same color. Metanotum cream with purplish markings. Pleura cream marked with light brown. Thoracic sternites cream; posterior of prosternum, anterior of mesosternum, and coxæ of middle legs marked with purplish brown.

Legs: Creamy white. On foreleg trochanter and dorsal aspect of femur streaked with rose. Joinings of femur, tibia and tarsus, as well as claw and most of fifth tarsal joint, dark purplish. Lavender mark near distal end of tibia. On other legs, claw and fifth tarsal joint, likewise joinings of last three tarsal joints, greyed lavender.

Wings: Costal border of fore wing yellowish. Vein C amber; other longitudinal veins in upper part of fore wing purplish brown. Cross veins purple-black.

Abdomen: Color pattern arranged very much as in male, but the anterior extensions of the lateral bands not approaching the median line. Thus a greater amount of ground color is visible between these lateral arms and the median longitudinal stripe. Median stripe dark greyish brown; on tergites 3-7, bifid anteriorly. Lateral marks same general color. Eggs within body give pink tinge to all anterior segments, before their deposition. Tergite 10 yellow. Ventrally, ganglionic areas white. A short purplish streak on median line at anterior of sternite 9 and indistinct purplish lateral marks on 10. Sternites 9 and 10 definitely yellow. No other ventral marks.

Tails: Creamy white, purplish black at joinings.

Holotype: ♂. Reared from nymph taken at Millwood, W. Va., by Prof. J. G. Needham. June 25, 1930. No. 920.1 in Cornell Univ. collection.

Allotype: ♀. Same as above. No. 920.2, in Cornell University collection.

Paratypes: ♂ imago, and ♂ and ♀ subimagos. Same. No. 920.3-7, in Cornell collection.

Hexagenia marilandica, n. sp.

A rather large species, superficially similar to *H. rosacea*, but anterior abdominal tergites lacking median stripe. Second tarsal joint of foreleg of male proportionately longer, and compound eye somewhat smaller.

MEASUREMENTS.

	Body	Tails	Foreleg	Fore-wing
Male imago (1 specimen)	18	48	12	16
Female imago (1 specimen)	27	36	8	25

MALE IMAGO

Head: Greyish white. Vertex cream-colored. Upper half of compound eyes slate grey. Ocelli with broad black basal ring, above this a narrower lavender ring. Dorsal aspect of median carina purplish black. Second antennal joint purplish, filament light brown. Compound eye is to space between eyes approximately as 1:1.

Thorax: Pronotum with yellowish tinge, the purplish brown longitudinal stripes rather broad and extending to wing base. Mesonotum and pleura creamy white, the former bordered and the latter marked with light brown. Metanotum creamy yellow with lavender markings. Prosternum white, two purple streaks between the legs. Mesosternum dark purplish rose anteriorly, its posterior portion light tan with lavender to rose marks on each side. Metasternum white, bordered laterally and posteriorly with purplish. Antecoxal pieces light tan flushed with rose.

Legs: Coxa and trochanter of foreleg purplish. Femur and tibia rose-red, darker at joinings. First tarsal joint, distal one-third of second to fourth joints, and all of the fifth joint with claws, purplish brown. Other legs creamy white. Coxa of second leg purplish red anteriorly. Claws, distal two-thirds of fifth tarsal joint, and joining of fourth and fifth, purplish brown.

Wings: Costal border of fore wing brown, darker in distal half but lighter again at apex. Longitudinal veins of fore wing brownish rose, cross veins purplish black in both wings. Several cross veins in each wing bordered with purplish black. No dark outer border on hind wing.

Abdomen: Ground color creamy white, flushed faintly with pink on dorsum; yellowish on 8-10. Greyish rose median longitudinal stripe on 6-10; indicated only as very faint grey line on 1-6. Tergite 1 purplish brown next to pleural fold and on anterior margin. Lateral oblique bands on 2-7 running from broad base on posterior margin on each side, laterally to pleural fold near anterior lateral angle. An upward and inward extension of each seems to join the base of the similar mark in the tergite directly anterior. Thus a zigzag pattern is formed along each side. On tergite 8 the lateral stripe is broader at base, more definitely rose-colored, and does not so clearly join the stripe of the anterior tergite. Tergite 9, this band is merely an extension laterally from the posterior border of the median stripe, and does not reach to the middle of the pleural fold. A small rose spot in anterior lateral angle. Tergite 10 yellow, a faint rose median stripe and two definite oblique lateral brown ones. Ventrally, the ganglionic area on each sternite indicated by a purplish mark, which on 7-9 extends more than half the length of the segment. On sternites 2-6, an oblique grey-rose mark arises from posterior border between median line and pleural fold, and extends forwards and inwards to about the middle of each side of each sternite. On 7-9, these marks are broader posteriorly and reach median line near center of sternite.

Tails: Near base, proximal half of each joint yellow, distal half dark reddish brown. In remainder of tail, each joint dark reddish brown, darker distally, except for yellow proximal ring.

Genitalia: Of the *carolina* type. Forceps base amber; penes and forceps same color. Basal and second joint of forceps limbs purplish brown. Penes with dark purplish brown longitudinal stripe. (Fig. 22).

FEMALE IMAGO.

Head: Creamy white. Median carina in dorsal aspect black distally, two dark streaks on each side near base. Ocelli ringed with black at base. Filament of antenna amber.

Thorax: Pronotum greyish white with broad purplish brown longitudinal stripes. Meso- and metanotum light tan with brown and amber markings. Pleura creamy white, with wide lateral suture to base of middle legs brown and amber; other sutures brown. Pro- and metasternum creamy white. Mesonotum yellowish tan with brown borders. Antecoxal pieces brownish lavender.

Legs: Foreleg, femur and tibia amber brown, greyish at joinings. Tarsus greyish yellow; fifth tarsal joint, claws and joinings greyed lavender. Other legs yellowish white. Claws, all but base of fifth tarsal joint, and narrow line at tarsal joinings, light greyed lavender.

Wings: Costal border of fore wing greyish yellow. Longitudinal veins in upper part of fore wing, and vein Sc of hind wing amber to light brown. Other longitudinal veins greyish. Cross veins of both wings purplish black.

Abdomen: Pale yellow dorsally, creamy white ventrally. Tergites 1 and 2 purplish grey on each side and on anterior border. Also with two short oblique grey bars from middle anterior border extending laterally from grey median line. Posterior lateral angle of 2 creamy white. 3-6 with grey triangle on median line, wider posteriorly. On 7-9, this median stripe is brownish grey, widened both posteriorly and anteriorly, darker at anterior border. Lateral oblique purple-brown marks on tergites 3-6 arising near anterior lateral angle, with wide arm extending downwards and inwards almost to posterior border at median line. Narrower arm extends parallel to anterior border, almost to median line. On 7-9 this mark arises from posterior border as wide extension of median line, and runs laterally almost to pleural fold, not extending above center of tergite. On these tergites also the marks become darker. Tergite 10 with narrow median stripe. Ventrally, a purplish black streak usually appears at each ganglionic area. No other ventral markings.

Tails: Yellowish, ringed with purplish black at each joining.

Holotype: ♂, imago. Taken at Conococheague Park, Washington Co., Md., June 3, 1925. Collected by Mr. Virgil Argo. No. 921.1, in C. U. collection.

Allotype: ♀, imago. Same. No. 921.2, in C. U. collection.

Paratype: ♀, imago. Same. This specimen lacks the purplish mark on ganglionic area, but otherwise corresponds with the female allotype. No. 921.3, in C. U. collection.

***Hexagenia carolina*, n. sp.**

A large species, predominantly yellowish white, male with greyed rose to lavender markings. No dark outer border on hind wing.

MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male subimago..... (2 specimens)	20-24	21-27	7- 8	15-16
Female subimago..... (5 specimens)	27-35	18-32	8- 9	22-25
Male imago..... (5 specimens)	20½-24	41-43	9-12	14½-17
Female imago..... (14 specimens)	25-32	35-45	10½-12	23-27

MALE IMAGO.

Head: Creamy white. Upper part of compound eye golden brown. Cream-yellow markings on vertex. Ocelli with black ring at base; one purplish spot near base of compound eye, another near median carina. Dorsal aspect of median carina purplish. Compound eye is to intervening space between eyes approximately as 1:1.

Thorax: Pronotum creamy white, with two longitudinal purplish streaks. Meso- and metanotum yellowish with light brown markings. Brown lateral streak on mesopleurum, to base of middle leg. Ventrally, coxæ of middle legs and median anterior portion of mesosternum purplish, remainder creamy white.

Legs: Femur of foreleg light rose, tibia deep rose. Short first joint of tarsus purple; second, third and fourth tarsal joints creamy white, purplish at joinings. Fifth joint purple-brown except at base, claws same color. Other legs creamy white. Narrow purple line at joinings of tarsal joints; claws and distal half of fifth tarsal joint purplish brown.

Wings: Fore wing yellowish brown on costal border, to R. Veins C, Sc, and R golden brown, other longitudinal veins and cross veins purplish brown, except in anal region. In hind wing, Sc and R purplish brown, other longitudinal veins yellowish white; cross veins purplish black. Outer margin not darker than rest of wing membrane; no conspicuous dark spots.

Abdomen: Creamy white background, segments 1-7; 8 faintly, 9 and 10 definitely yellow. Posterior border of each tergite creamy white. Tergites 1-6 with faint grey median streak; 7-10 with rather broad greyed lavender median streak. Oblique lateral grey-rose mark on each side of each tergite from near posterior border medially to anterior lateral angle. On 1, this is more brownish and occupies most of each side of the tergite, with extensions along the anterior border to median line. On 2-6, extensions to median line as in 1, but narrower; 6, lateral marks joined posteriorly. 7-9, marks arise as arms from broad median stripe, on 8 and 9 not reaching anterior margin. 10 with faint purple-brown lateral line. Ganglionic area on sternite 6-10 purplish brown; on 1-5 indicated only by a white circle. Faint indication of yellow median streak on 8 and 9, and of yellowish triangle on 7, its base on posterior border. No other ventral markings.

Tails: Joints reddish brown, darker distally, very dark at joinings. Proximal end of each creamy white to light tan. Extreme distal end of tails creamy white.

Genitalia: Of the *carolina* type. Basal joint of forceps limb equal to one-half of second joint. Second joint swollen distally; the two short end joints of medium size. Purplish black line on basal joint on outer side at base, and on inner side distally. Tip of second joint purplish, two distal joints brown. Penes with purple lateral stripe on outer margin. (Fig. 20).

FEMALE IMAGO.

Head: Yellowish—in life, sulphur-yellow. Markings as in male; second antennal joint brown.

Thorax: Pronotum greenish yellow with indistinct brown longitudinal stripes. Mesonotum flesh-colored, bordered by light brown. At base of wing in living specimen, two triangular olive patches. Metanotum yellow. Pleura and sternites flesh-colored, sutures yellow. In some specimens, mesosternum also yellow.

Legs: Yellow. On foreleg trochanter, spot on outer femur near distal end, and distal end of tibia, purplish rose. All joinings, claws and distal two-thirds of fifth tarsal joint purplish brown. Other legs with but indistinct lines of color at joinings, claws yellowish basally and dark grey distally; last tarsal joint as in foreleg.

Wings: Amber or yellow tinted throughout. Main longitudinal veins yellow to whitish, cross veins rose to purple.

Abdomen: Pale yellow when eggs have been deposited, flesh-colored to salmon-pink before this. Prominent median stripe on tergites 7–10 as in male, its narrow extension forward to tergite 1, yellow. In life, this median line on 8 is bordered with greenish, and posteriorly with sulphur-yellow spots near pleural folds. Not green on 9, but more yellow. Markings of tergites very similar in position to those of male, but narrower and less extensive, in color dull lavender. Ventrally, ganglionic areas as in male, but purplish streaks on 6–10 very narrow or lacking. Sternites 8–10 sulphur-yellow.

Tails: Yellowish white, very indistinctly more grey at joinings.

Holotype: ♂, imago. Taken at Hamburg Lake, on Brush Creek, 10 miles north of Greensboro, N. C., June 6, 1929. No. 916.1, in C. U. collection.

Allotype: ♀, imago. Same place, same time. No. 916.2, in C. U. collection.

Paratypes: 1 ♂, 4 ♀s, imagoes; 1 ♂, 3 ♀s, subimagoes. Same place, same time. No. 916.3–11, in C. U. collection.

Hexagenia carolina was first captured at Hamburg Lake, a small artificial lake owned by a local angling club. Shortly after 8 P. M., on June 1, as we were driving along the highway between Greensboro and Summerfield, a considerable number of large yellowish female *Hexagenias* appeared, flying toward the headlights. On parking the car, it was discovered that no collecting net had been put in, but the big mayflies were flying so slowly and so close to the road that it was possible to capture many of them by hand, literally picking them out of the air as they passed. Many fell to the road and were crushed by passing autos. They were most numerous near the bridge

over the outlet of the lake. All taken that evening were subimago females.

Three days of cool weather were followed on June 6 by a warmer evening, and we returned to the lake, arriving in time to see many of the *Hexagenias* emerging from their nymphal skins at the surface of the water. They rose quite high almost at once, flying straight toward the tree tops. They could be taken only with the net, and the majority escaped it. When the lights of the car were turned on, two subimago males were taken, along with several more females. Another trip to the lake on June 7 yielded many more females and several males. On this evening also, we were able, by the use of a flashlight, to collect great numbers of nymphal skins, as they floated downstream toward the overflow on one side of the dam.

Many subimagoes of both sexes were kept until they attained the imago state. One male required 22 to 23 hours to complete its transformation, another male 23 to 24 hours. Three females varied from $22\frac{1}{2}$ to $26\frac{1}{2}$ in their subimaginal state.

Nymphs which seem to correspond identically with the nymph skins taken at Hamburg Lake were found in the mud along one bank of the South Toe River, near Micaville, N. C., on July 3, 1930. None of these transformed.

Hexagenia carolina (?) On the morning of June 27, 1929, a fine male was found on the door screen of a house at Franklin, N. C., on a bluff just above the Little Tennessee River. On the evening of July 3, two female subimagoes were taken as they arose from the river, and many others were seen but could not be captured. These two females were kept until they transformed into imagoes.

The females seem very similar to those taken at Hamburg Lake, but the male exhibits certain differences from the males of *H. carolina* taken at that lake. It differs in these respects: tails 55 mm. in length, light reddish brown with wide dark brown markings at joinings; distal end of second joint of forceps not swollen, as in typical *H. carolina*; ganglionic markings extend anteriorly to segment 4, indistinctly to 2; upper part of eye slate grey instead of golden brown.

When more specimens can be obtained, it may be apparent that these taken at Franklin are a different species. Meantime I leave them tentatively under *H. carolina*.

***Hexagenia weewa*, n. sp.**

A large species, the females bright canary yellow, the males marked with purplish brown. Hind wing of male with purplish outer border and with dark spots.

MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male imago..... (4 specimens)	22-24	55-67	17-19	17-19
Female imago..... (13 specimens)	24½-30	40-47	10-12½	24-28

MALE IMAGO.

Head: Yellowish white. Upper half of compound eyes purplish grey. Ocelli ringed at base with greenish, above this with a wider band of amber brown. Dorsal aspect of median carina brownish at tip, black in center. Second antennal joint and proximal portion of filament amber brown. Compound eye is to space between eyes approximately as 1:0.75.

Thorax: Pronotum light tan, longitudinal stripes purplish brown, extensions to wing base brown. Mesonotum creamy white bordered with brown. Metanotum yellowish. Pleura of mesonotum brown, other pleura yellowish to brownish. Prosternum anteriorly creamy white, posterior half very dark purplish brown. Anterior portion of mesosternum and all of metasternum dark purplish brown. Posterior of mesosternum lighter shade of same color.

Legs: Ventral of coxa and all of trochanter, femur, tibia and first tarsal joint of foreleg mahogany brown. Proximal half of tarsal joints two to four yellow; distal half purplish brown. Fifth tarsal joint and basal half of claws dark purplish brown, claws distally dark grey. Other legs yellowish white, very faint purple line at tarsal joinings. Claws pearl-grey ventrally, brownish dorsally. Fifth tarsal joint purplish brown except at base.

Wings: Costal margin of fore wing, to R, reddish brown. C, Sc and R brown, other longitudinal veins of both wings purplish brown. Cross veins purplish black. Hind wing with purplish outer margin, and several purplish black spots in usual area.

Abdomen: Ground color white, sometimes faintly tinted with lavender; 8-10 faintly yellowish. Tergites with well-defined median longitudinal streak. Wide and dark purple on 7-9, somewhat narrower on 1-6 and 10. On 1-6 greyish purple, bifid anteriorly. Purplish brown oblique lateral marks arise from anterior lateral angles of tergites 1-7, extending backwards and upwards, but not reaching posterior border. On 1 and 2 these marks are triangular, with base on pleural margin, and narrow extensions along the anterior border to median line. On 3-7 the triangular appearance gradually gives way to an elongated streak with pointed free ends. On 8 and 9 these marks are outward extensions of the median longitudinal stripe, and do not attain the anterior margin. 10 yellowish, with oblique lateral brownish bars.

Ventrally, the ganglionic area in each sternite marked with purplish black. An irregular lavender-brown triangle on sternites 1-9, becoming narrower on 8 and 9. Its apical third lighter lavender, defined laterally by two brown streaks. In center of each sternite, on each side of median line, a small clear round spot. Sternites 1-5 and 8, with narrow purple posterior border.

Tails: Basal joints light brown, dark brown at joinings. In remainder of tail, joints dark reddish brown, slightly darker distally, each with a narrow yellow proximal ring.

Genitalia: Of *carolina* type. Forceps base purplish brown. Basal joint of forceps limb on ventral side streaked with purple. Distal end of second joint, and both end joints, greyed lavender. Penes greyish, with purplish brown ventral streak. Remarkable for the great relative length of the second joint of the forceps limb, which is three-fifths the length of the first. The end-joints, especially the third, are likewise unusually long and stout. (Fig. 17).

FEMALE IMAGO.

Entire body clear canary yellow. Ocelli as in male. Median carina black at base and near distal end. Purplish-brown spot between ocellus and compound eye.

Thorax: Faint purplish-grey streak on pronotum. Pleurum and sternum of mesothorax flushed with orange.

Legs: Light yellow, first pair with lavender marks on trochanter, streak near base of femur, and mark near base of tibia, almost encircling it. Joinings of tarsus, and all but base of fifth tarsal joint, also blunt claw, dark purplish-brown. Pointed claw amber with purple mark. Claws and fifth tarsal joint of other legs similar. Faint purple line at tarsal joinings, no other marks.

Wings: Tinted throughout with clear amber yellow. Longitudinal veins in upper half of fore wing canary yellow, all others white to yellowish. Majority of cross veins purplish black.

Abdomen: Tergites with median longitudinal stripe and lateral oblique marks, much as in male, but latter less intense in color. On 7, the lateral mark arises from purple streak near posterior border of tergite and extends forwards and outwards. All tergites bordered posteriorly with white along central portion. Purple spot on anterior part of pleural fold on sternite 9. Ventrally, purplish black median line marks each ganglionic area.

Tails: Yellowish white, each joining with white proximal ring.

Holotype: ♂, imago. Taken at Chipola Lake, Fla., near the village of Weewa-hitchka, by Prof. J. G. Needham, April 8, 1927. No. 918.1, in C. U. collection.

Allotype: ♀, imago. Same as above. No. 918.2, in C. U. collection.

Paratypes: 3 ♂s, 13 ♀s. Same as above. No. 918.3-17, in C. U. collection.

Of the collecting of *Hexagenia weewa*, Prof. Needham gives the following account:

"The capture of *Hexagenia weewa* occurred on this wise. Prof. C. R. Crosby and I were passengers on the Apalachicola River steamboat *John C. Callahan, Jr.* On the evening of the eighth of April, this big boat ventured up the Chipola River above Dead Lake to Cotton Bluff to take on some barrels of turpentine. Near Cotton Bluff the boat got stuck in one of the bends of that crooked little stream just at nightfall. The searchlight was turned on, and in the beam of light that it cast upstream the mayflies rose above the black waters by thousands. Along with multitudes of midges and a few other mayflies of the genus *Ephemerella*, the big yellow female *Hexagenias* came fluttering up to the light. They settled all over the front of the boat, two or three layers deep wherever there was support. They flew in our faces and clung to our clothing. One could gather them up by barrelsful. But among the many thousands of females, only two or three males were seen."

Hexagenia rosacea, n. sp.

A rather large species, superficially similar to *H. carolina* and *H. marilandica*. Distinguishable from the former by the brighter and more extensive color pattern, the shorter femur, and by the genitalia. From the latter it may be distinguished by the greater amount of color on the anterior abdominal tergites, the shorter second tarsal joint, and by the genitalia. The compound eye is also proportionately larger than in either of these species.

MEASUREMENTS.

	Body	Tails	Foreleg	Fore-wing
Male imago .	20	50	12	17

MALE IMAGO

Head: Greyish white. Median carina in dorsal aspect rose distally, base black. Upper portion of compound eye cream-colored. Ocelli with black ring at base, rose ring above this. Cream-colored markings on vertex. Filament of antenna rose, basal joints cream. Compound eye is to the space between the eyes approximately as 1:0.75.

Thorax: Pronotum greyish white, with two longitudinal purplish-red streaks extending to wing bases. Mesonotum whitish with cream-white markings, bordered by rose-brown. Metanotum yellow with rose markings. Prosternum white with faint lavender streak posteriorly. Mesosternum very deep rose, shading to light rose and with white posterior border. Metasternum purplish rose. Pleura white with lateral rose stripes to base of middle legs.

Legs: Coxa posteriorly in distal half, trochanter and femur of foreleg rose. Tibia deep rose. First short tarsal joint, and distal third

of second to fourth joints, very deep purplish rose. Fifth joint except at base, and claws, same color. Other legs white, tarsal joinings with narrow purplish line. Blunt claw and distal two-thirds of fifth joint of tarsus purplish grey, pointed claw lighter shade of same color.

Wings: Very iridescent. Costal margin of fore wing, to R, light brown in basal half, dark brown distally. Veins C, Sc, and R of fore wing golden brown, other longitudinal veins dark purple. Hind wing without dark outer margin.

Abdomen: Ground color white on segments 1-6, definitely yellow on 7-10. Dorsally, rather wide median stripe on all tergites, greyish brown on 1-5, reddish brown on 6-10; becomes progressively wider from 7-9. Tergites 1 and 2 dull rose-grey except for white mark near pleural fold, another on each side near anterior margin, and pinkish crescent on posterior margin at median line. 2-7 with deep rose oblique lateral stripes from anterior lateral angle to posterior margin, joining median stripe. Lateral stripe becoming wider on 6 and 7. Narrow extension along anterior margin halfway to median line. 3 with pink crescent as in 1 and 2. 4-9 with deep rose posterior border. 8 and 9, lateral mark becomes a short wide extension of median stripe from posterior margin, not attaining anterior margin. 10 bright yellow at bases of tails, brown oblique line on each side. Pleural folds white, yellowish on 8 and 9. Ventrally, ganglionic area marked in each sternite by dark rose streak. Sternite 1 with rose triangle, its base on posterior margin, its apex halfway to anterior margin. Sternites 2-10 bordered posteriorly with deep rose. On each side a small deep-rose triangle, base on posterior margin, extending forward less than half the length of each sternite.

Tails: Near base, each joint yellow proximally, deep rose in distal half, with wide reddish-black ring at joining. Near center of tail, joints yellow proximally, dark brown in distal two-thirds, darker at joining. More distally, joints dark brown throughout, save for narrow light proximal ring.

Genitalia: Of *carolina* type, the distal forceps joints somewhat less slender than in *H. carolina*. Forceps limbs golden yellow basally, becoming tinged with reddish brown on distal joints. Penes golden yellow, streaked longitudinally with rose-brown. (Fig. 10).

Holotype: ♂, imago. Taken on window screen at Penrose, N. C., near headwaters of French Broad River, July 14, 1930. No. 922.1, in C. U. collection.

***Hexagenia orlando*, n. sp.**

A rather small species. Fore wing of male with reddish brown costal border; narrow purplish outer margin on hind wing. Ground color of abdomen of male yellow to light tan, with dark brown markings. Female marked in purple.

MEASUREMENTS.

	<i>Body</i>	<i>Tails</i>	<i>Foreleg</i>	<i>Fore-wing</i>
Male imago..... (12 specimens)	14-18	36-45	9-13	11-14
Female imago..... (1 specimen)	17	21	?	15

MALE IMAGO.

Head: Upper part of compound eye golden brown. Ocelli with greyish-black basal ring and purplish brown ring above this. Second antennal joint purplish brown, filament light brown. Vertex marked with greyish purple near center, with orange laterally and posteriorly. Occiput purplish, an orange mark on each side next to compound eye. Dorsal aspect of median carina dark purplish, grey at tip. Diameter of compound eye is to space between eyes approximately as 1:0.75.

Thorax: Pronotum light tan, longitudinal stripes dark purple-brown. Mesonotum yellowish tan, greenish centrally, in the anterior three-fourths. Brown spot in center in posterior fourth. Bordered laterally and posteriorly with golden brown and cream. Metanotum yellowish brown with cream markings centrally and posteriorly. Pleura yellowish to golden brown with cream markings; sutures brown. Anterior half of prosternum yellow, posterior half dark brown with purplish streak between legs. Meso- and metasternum golden brown laterally, and on posterior of mesosternum; medially reddish brown. Posterior of mesosternum bordered with reddish brown.

Legs: Coxa and trochanter of foreleg dark brown; femur and tibia dark reddish brown, darker at joinings. First tarsal joint dark brown; second to fourth yellow basally, purplish brown distally. Fifth tarsal joint and claw purplish brown. Other legs yellow. Joinings of tibia and tarsus and of all tarsal joints, also claw and fifth tarsal joint, purplish brown.

Wings: Fore wing with reddish brown costal border. Hind wing with narrow purplish brown outer margin. In fore wing a few cross veins narrowly margined with purplish black; in hind wing, several widely margined. Longitudinal veins in both wings golden brown, cross veins purplish black.

Abdomen: Ground color yellow to light tan, becoming deep yellow on segments 8-10. Median dorsal line with rather broad blackish-brown stripe on tergites 6-9, and with narrower dark grey streak on 1-5, in these latter tergites wider anteriorly. On 10 this median line is narrow and black. On 1-7, an oblique lateral band arises at the anterior lateral angle and extends backwards and inwards to join the median stripe at the posterior margin. Each of these bands is wide anteriorly, narrow posteriorly, except on 7, where the reverse is true. On 8 and 9 these marks arise from the center of the median stripe at the posterior border, and occupy the entire posterior lateral angle. A narrow extension may continue up along the pleural fold to the anterior margin. Ventrally, a purplish-brown streak marks each ganglionic area; another similarly-colored faint mark occurs in each anterior lateral angle of sternites 1-8. Sternite 1 may show two

clear round spots in center, one on each side of the median line. On 9, an orange triangle with base on posterior margin, extends to anterior margin. On 1-8, the sides of similar triangles are faintly indicated as brown slightly wavy lines.

Genitalia: Of the *carolina* type, quite slender, the second joint of the forceps limb slightly more than twice as long as the first joint. Forceps base and first joint of forceps limb amber brown with cream markings. Second joint greyish white in basal half, purplish brown distally. End joints light purplish brown, dark brown at joining. Penes dark brown ventrally, yellow dorsally. (Fig. 13).

Tails: At base, each joint yellow proximally and light brown distally, dark brown at joinings. In all the remainder of the tail except at tip, each joint dark reddish brown with narrow proximal yellow ring, joinings dark brown to black. At tip, joints light brown, joinings black.

FEMALE IMAGO.

Head: Yellow. Upper part of compound eye dark grey. Occiput and vertex mottled with dark brown. Ocelli ringed with black at base, and black spot laterally next to compound eyes. Dorsal aspect of median carina black. Antennal filament light brown.

Thorax: Pronotum yellowish with purplish-brown longitudinal stripes. Mesonotum straw yellow bordered with darker yellow, and with grey markings. Metanotum yellow marked with black. Pleura cream to light yellow. Prosternum light yellow, dark streak between legs. Meso- and metasterna brighter yellow, no definite markings.

Legs: Foreleg missing, from only specimen available. Other legs straw yellow; the claws, fifth tarsal segment and joining of other joints of tarsus, faint greyed lavender.

Wings: Fore wing with faint yellow costal border. Longitudinal veins of both wings golden yellow, cross veins purplish brown.

Abdomen: Creamy white, yellowish on 8-10. Tergites with greyed purple markings, somewhat as in male. Wide median band on tergites 6-10, on 6 and 7 expanding anteriorly and giving off two lateral arms toward center of each side of tergite. Same median band on 1-5, but not so wide, expanded in the anterior half and the lateral fan-shaped arms more prominent (except in 1) than on 6 and 7. Lateral oblique stripes arise from anterior lateral angles of tergites 1-7, expand widely in center of each side, becoming narrower as they join the median band at the center of the posterior border. On 1 and 2 these stripes are so wide as almost to obliterate the white triangle in the posterior lateral angle. On 8-10 these stripes arise from the posterior median line as extensions of the median stripe, proceeding forwards and outwards to pleural fold; a narrow line may then extend along pleural fold to anterior border. Ventrally, each ganglionic area is indicated by a purplish-black triangle or streak. On 10, two oblique black lines on each side of center of sternite. No other ventral markings.

Tails: Greyish white, marked at each joining with dark maroon.

Holotype: ♂, imago Taken at Orlando, Fla., by Mr M D Leonard, May 20, 1927 No 919 1, in C U collection

Allotype: ♀, imago Same location and collector, June, 1926. No 919 2, in C U collection

Paratypes 11 ♂s Same as holotype No 919 3-13, in C U collection

KEY TO HEXAGENIA MALES

- 1 Both wings suffused throughout with bronze *H. recurvata*
Wings in large part hyaline 2
- 2 Costal margin of fore-wing light brown in proximal half, dark brown distally, hind wing heavily bordered with purplish brown along outer edge, this border occupying approximately one-fourth the length of the wing *H. atrocaudata*
Wings not as above 3
- 3 Costal border of fore-wing heavily bordered with brown, hind wing with evident brown outer margin, but this border not occupying one-fourth of the wing 4
Hind wing lacking brown border on outer margin, fore wing usually with costal margin darker than rest of wing 11
- 4 Fore wing under 15 mm in length 5
Fore wing over 15 mm in length 7
- 5 Both wings definitely tinged with yellow or greenish yellow *H. venusta*
Wings not tinged with yellow or greenish yellow 6
- 6 Fore wing under 13 mm in length, both fore and hind wings with numerous dark spots *H. elegans*
Fore wing over 13 mm in length, fore wing lacking dark spots *H. mingo*
- 7 Bilineata type of genitalia, both wings tinged with light brown *H. bilineata*
Genitalia and wings not as above 8
- 8 Rigida type of genitalia, abdominal tergites each with two bright yellow triangular spots based on the anterior margin *H. rigida*
Genitalia and abdominal markings not as above 9
- 9 Carolina type of genitalia abdominal tergites whitish with oblique purplish brown markings *H. weewa*
Limbata type of genitalia abdominal tergites dark brown with paler markings 10
- 10 Fore wing 18 mm in length, costal margin dark red-brown throughout, eye unusually large *H. viridescens*
Fore wing 17 mm in length, costal margin yellowish brown, lighter in proximal half, eye not unusually large *H. occulta*
- 11 Both wings tinted almost uniformly with light bistre-grey, costal margin of fore wing distinctly bistre-grey *H. munda*
Wings not uniformly tinted with grey, costal margin of fore wing brown 12
- 12 Fore wing not exceeding 15 mm in length *H. orlando*
Fore wing exceeding 15 mm in length 13
- 13 Wings tinted lightly with greenish yellow *H. limbata*
Wings not tinted with greenish yellow 14
- 14 Fore wing over 19 mm in length, abdominal tergites dark brown, marked on each side with yellow spots not based on the anterior margin, *H. affiliata*
Fore wing under 19 mm in length, abdominal tergites whitish with rose to red markings 15
- 15 Fore and hind wings with dark spots, anterior abdominal tergites without median stripe *H. marilandica*
No spots in fore wing, few in hind wing, anterior abdominal tergites with median purplish-brown stripe *H. rosacea*

KEY TO HEXAGENIA FEMALES.

(NOTE.—Females of *H. munda* and *H. rosacea* not included.)

1. All principal longitudinal veins, and majority of cross veins, of both fore and hind wings, heavily bordered with dark reddish brown.... *H. recurvata*
Wings not as above..... 2
2. Outer margin of hind wings and costal margin of fore wings bordered with brown..... 3
No brown border on outer margin of hind wings; fore wings may have brown or yellow costal margin..... 6
3. Fore wing under 20 mm. in length..... 4
Fore wing over 20 mm. in length..... 5
4. Hind wing heavily bordered with purplish brown; costal margin of fore wing dark brown in distal half, light brown in proximal half... *H. atrocaudata*
Hind wing narrowly bordered with reddish brown, and with numerous dark spots; costal border of fore wing dark brown in proximal half, light brown in distal half..... *H. rigida*
5. Fore wing over 25 mm. in length; hind wing faintly bordered with greyish brown..... *H. viridescens*
Fore wing under 25 mm. in length; hind wing with prominent brown border, and with several distinct black spots..... *H. bilineata*
6. Wings tinted throughout with yellow or greenish yellow..... 7
Wings not definitely tinged with greenish yellow or yellow throughout..... 9
7. Fore wing under 24 mm. in length..... 8
Fore wing over 24 mm. in length..... *H. weewa*
8. Fore wing tinged with greenish, especially on costal border. Several cross veins near base of Sc and R margined with brown..... *H. elegans*
Both wings strongly tinged with greyish yellow. Cross veins near base of Sc and R not margined with brown as above..... *H. venusta*
9. Fore wing 23 mm. or over..... 10
Fore wing under 23 mm..... 11
10. Main cross veins and portions of many principal longitudinal veins of both wings rose-colored..... *H. carolina*
Main cross veins of both wings purplish black. Veins C, Sc and R of fore wing, and Sc of hind wing, light brown; other longitudinal veins grey..... *H. marilandica*
11. Fore wing 20-22 mm. in length..... 12
Fore wing less than 20 mm. in length..... *H. orlando*
12. Costal border of fore wing reddish brown; cross veins purplish rose..... 13
Costal border of fore wing yellowish; cross veins purple-black..... 14
13. Wing 22 mm. in length; abdomen marked with very dark red-brown, *H. affillata*
Wing 20 mm. in length; abdomen marked with purplish brown.... *H. occulta*
14. Veins C and Sc yellowish, other veins greyish white..... *H. limbata*
Vein C amber; other longitudinal veins in upper part of fore wing purplish brown..... *H. mingo*

TABULATION OF CHARACTERS.

HEXAGENIA MALES.

SPECIES	Gen.	Wing	F : tb	Tb : t	T. jts.	Th.	Abdom.	Pattn.	Eye	F. lg : body
<i>recurvata</i>	III	15-18	1:2	1:1	1:1.2	dark brown	yellow	light brown	yellow tan	1:1.4
<i>atrocaudata</i>	V	19½	1:1.7	1:1	1:1	v. dark brown	yellow	dark brown to bl.	orange	1:2
<i>bilineata</i>	II	16	1:1.6	1:1.5	1:1.3	v. dark brown	red-brown	dark brown to bl.	dark brown	1:1
<i>limbata</i>	I	13-15	?	?	?	?	yellow	dark brown	green-yellow	?
<i>rigida</i>	IV	16	1:1.9	1:1.5	1:1.1	dark brown	yellow	dark brown	dark brown	1:1.4
<i>viridescens</i>	I	18	1:1.7	1:1.3	1:1.2	v. dark brown	dk. red-brown	light brown	dark brown	1:1
<i>affinisata</i>	I	19½	1:1.6	1:1.2	1:1.2	dark red	yellow	dark brown to bl.	dark green brown	1:1.4
<i>occulia</i>	I	17	1:1.7	1:1.2	1:1.3	dark red-brown	red-brown	dark red-brown	v. dark brown	1:1
<i>munda</i>	I	14	?	?	?	brown	yellow	brown to bl.	?	?
<i>remota</i>	I	13-16	1:1.8	1:1.2	1:1	dark purple brown	yellow	purple brown	dark grey	1:1.3
<i>carolina</i>	VI	14-17	1:1.2	1:1.5	1:1.1	red-brown	creamy white	greyed rose	golden brown	1:2
<i>rosacea</i>	VI	17	1:1.7	1:1.3	1:1.1	dark red	creamy white	deep rose	cream	1:1.7
<i>marilandica</i>	VI	16	1:1.7	1:1.4	1:1.5	dark red	creamy white	deep rose	slate grey	1:1.7
<i>mingo</i>	I	14½	1:1.7	1:1	1:1	dark brown	creamy white	red-brown	cream	1:1.5
<i>orlando</i>	VI	12-14½	1:2	1:1	1:1.2	light tan	light tan	dark brown	golden brown	1:1.5
<i>elegans</i>	VI	10-12	1:1.5	1:1.2	1:1.2	purple rose	creamy white	deep rose	golden tan	1:1.7
<i>weewa</i>	VI	17-19	1:1.9	1:1.4	1:1.2	purple brown	white	dark purple brown	purple grey	1:1.2

EXPLANATION OF ABBREVIATIONS USED IN TABULATION OF CHARACTERS.

Gen.—genitalia type.

I—type limbata.

II—type bilineata.

III—type recurvata.

Wing—length of fore wing.

F : tb.—proportionate length of femur to tibia.

Tb : t.—proportionate length of tibia to tarsus.

T. jts.—proportionate length of 3rd to 2nd tarsal joints.

Th.—color of thoracic sternites.

Abdom.—general groundcolor of abdomen.

Pattn.—general color pattern of abdomen.

Eye—color of upper portion of compound eye.

F. lg:body—proportionate length of fore leg to body.

IV—type rigida.

V—type atrocaudata.

VI—type carolina.

THE NYMPHS.

A comparative study of eleven species of *Hexagenia* nymphs seems to indicate that only a few of the external structures show sufficient variation between species to serve as a basis for classification. Of these, the most important are (1) the shape of the frontal process of the head, and (2) the mandibular tusks. Of secondary importance are (1) the maxillæ, (2) the claws, and (3) the tails. In one species only, *H. recurvata*, the structure of the antennæ and the first rudimentary pair of gills serve as distinctive characters. The color of the body, the color pattern, and the color of gills and tails may be useful to supplement structural differences.

The frontal process may be square-cut or truncate, as in *H. atrocaudata*, (see plate, Fig. 1, d); angular, as in *H. recurvata*, (plate, Fig. 1, b); conical, as in *H. carolina* (plate, Fig. 1, c); or dome-shaped, as in *H. mingo* (plate, Fig. 1, a). In some species, as in Nymph No. 3, this process may be dome-shaped in the female and conical in the male. In the tabulation of nymphal characters, the head of the female has been considered, and any variations in the frontal process of the male are indicated in the brief description of each species.

The relative length of the head and of that portion of the tusks protruding beyond it is indicated for male and female in the tabulation. The tusks of the female are larger and longer than those of the male. Since, however, the head of the female is likewise wider and longer than that of the male, the relative length of tusk protruding beyond the head may be greater in the case of the male. The amount of curvature of the tusks is also characteristic. These show the least curvature in *H. recurvata*, in which species they are likewise provided with long hairs from base to tip, on the outer margin. The tusks of the other nymphs studied have hairs on the outer margin only in the basal half, the distal half being hairy on the inner margin only. The tusks of *H. carolina* are the longest.

The relative length of the maxillary palp to that of the entire length of the maxilla, and of the length of its first joint to the galea-lacinia, seem to be fairly constant specific characters. The third claw has been considered as being the least subject to injury and other modifications from external sources. Figures of the third claw of each species are given (Figs. 2, 3, 8, 9),

and show specific variations. The outer tails are stouter than the middle one, in all these species, and in most cases slightly shorter. In *H. bilineata* the tails of the male are proportionately much longer than those of the female. The color of the tails, and the presence or absence of darker rings at the joinings, seem to be specific.

In *H. recurvata*, the antennæ have only short inconspicuous hairs throughout their entire length, while in all the other species the antennæ possess very long hairs in that region from near the base to beyond the middle, and very short hairs at the tip. In *H. recurvata* likewise, the first rudimentary gill is simple, not bifid as in all the others.

DESCRIPTION OF NYMPHS.

Hexagenia bilineata.

Tusks reddish brown, gently upcurved in distal half. First joint of maxillary palp shorter than galea-lacinia. Palp less than twice length of body of maxilla. Outer tails banded indistinctly at joinings with greyish red-brown. Tails of males proportionately longer than those of females. Head and pronotum dark red-brown. Meso- and metathorax and legs red-brown. Abdominal tergites pinkish grey, each margined and bordered with grey and marked with red-brown. Ventrally light red-brown. Gills red-brown in center, fringes reddish grey. Body long and slender. Claws long and slender, not curved at tip; base slightly swollen.

Distribution: Iowa—Fairport, Andalusia Chute, Keokuk.

Hexagenia recurvata.

First rudimentary pair of gills simple, not bifid as in other species. Tusks red-brown; short and stout, only slightly upcurved. Fringed with long hairs on entire outer margin. First joint of maxillary palp equal in length to galea-lacinia. Palp less than twice length of body of maxilla. Middle tail greyish white. Head and pronotum light red. Meso- and metanotum darker red. Legs yellowish tinged with red. Abdominal tergites red-brown, margins and joinings light tan. Gills dark purplish grey in center, fringes light purplish grey. Anterior abdominal segments and thorax stout. Head and posterior abdominal segments relatively slender. Claws moderately stout, swollen at base, tip slightly curved.

Distribution: New York—McLean, Freeville, Michigan Hollow; Massachusetts—Granby; West Virginia—Moore's Creek at Wardensville; Michigan—Marquette Co.

Hexagenia atrocaudata.

Tusks red-brown, very dark distally; curve outward and downward basally, strongly upward distally. First joint of maxillary palp longer than galea-lacinia. Palp twice the length of body of maxilla. Middle tail yellowish. Head, dorsum of thorax, legs and last two abdominal tergites yellow-brown margined and marked with yellow. Anterior abdominal tergites and ventral surface grey-white, tinged with lavender. Gills very dark purple in center, fringes dark grey-purple. Body stout. Claws broad and short, swollen at base; tip slightly curved.

Distribution: New York—Ithaca (Beebe Lake). Reared by Prof. J. G. Needham. Indiana—Howe; West Virginia—'Smoke Hole,' Wardensville, Athens, Greenbrier River, Marlinton.

Hexagenia carolina.

Tusks red-brown, darker distally. Very long, almost equalling front leg in length. Upcurved distally. First joint of maxillary palp equal to or slightly longer than galea-lacinia. Palp not quite twice length of body of maxilla. Middle tail very light yellow. Head and dorsum of thorax yellow-brown. Abdominal tergites greyish lavender margined with white. Ventral surface white. Gills dark purple in center, fringes dark greyish purple. Body moderately stout. Claws short and stout, swollen at base; very short pointed tip, slightly curved.

Distribution: North Carolina—Hamburg Lake, near Greensboro, South Toe River, at Micaville.

Hexagenia mingo.

Frontal process tending toward conical, in some males. Tusks yellowish brown, extreme tip dark red-brown. Medium in length, only slightly upcurved. First joint of maxillary palp shorter than galea-lacinia. Palp almost twice length of body of maxilla. Outer tails of male grey-lavender at joinings, these bands at base alternately wide and narrow. Middle tails of both sexes white. Head and dorsum of thorax red-brown. Legs creamy white. Abdominal tergites creamy white, marked with purplish grey. Ventrally creamy white. Gills dark grey-purple in center, fringes lighter grey-purple. Body rather slender. Claws rather slender, base very little swollen. Tip somewhat curved.

Distribution: West Virginia—Millwood, reared by Prof. J. G. Needham.

Nymph No. 1.

Tusks yellowish brown; extreme tip dark red-brown. Medium in length, upcurved at tip. First joint of maxillary palp almost equal to galea-lacinia. Palp less than twice length of body of maxilla. Outer tails of male light grey with purplish-black joinings. Middle tail of male, and all tails of female, light yellow. Head and dorsum of thorax dark brown in male, in female slightly lighter. Abdominal tergites white; in male marked with purplish brown, in female with light grey,

Ventrally creamy white; dark ganglionic streaks on sternites 6-9, less distinct in female. Gills bluish purple in center, fringes same. Body stout. Claws short and stout, swollen at base; tip slightly curved.

Distribution: West Virginia—Wheeling, Grass Lick Run; Virginia—Mountain Lake.

Nymph No. 2.

Note: These specimens not fully matured.

Tusks yellowish brown, extreme tip very dark brown. Medium in length. Rather strongly upcurved distally. First joint of maxillary palp equal to galea-lacinia. Palp almost twice length of body of maxilla. Middle tail white. Head light yellow-brown. Thorax and legs creamy white. Abdominal tergites bluish white marked with purplish grey. Ventrally creamy white. Gills light purple-grey in center, fringes same color but lighter. Body very slender. Claws very slender and long.

Distribution: North Carolina—Pacolet River, near Tryon.

Nymph No. 3.

Note: Markings of these nymphs are strikingly similar to the color pattern of mature *H. rigida*.

Frontal process of male conical. Tusks light red-brown throughout length. Medium in length, gently upcurved. First joint of maxillary palp shorter than galea-lacinia. Palp less than twice length of body of maxilla, which is quite stout. Middle tail yellowish white. Head and dorsum of thorax red-brown. Legs yellow. Abdominal tergites purplish brown, marked and margined posteriorly with cream. Ventrally, thorax grey-white. Abdominal sternites cream, with dark ganglionic streaks on 6-9 in female. Gills purplish-black in center, fringes dark purple-grey. Body long and slender. Claws rather short, fairly slender, not swollen at base.

Distribution: Michigan—Alcona Co.

Nymph No. 4.

Tusks greyish yellow, dark red-brown at extreme tip. Medium in length, gently upcurved. First joint of maxillary palp almost equals galea-lacinia. Palp less than twice length of body of maxilla. Middle tail white. Head and dorsum of thorax light brown. Legs white. Abdominal tergites bluish white marked with purplish grey. Ventrally white; with dark ganglionic streaks on 6-9 sternites of both sexes. Gills dark purple-grey in center, fringes very light purple-grey. Body slender. Claws very long and slender.

Distribution: Florida—Gainesville and Torreya.

Nymph No. 5.

Note: Of this species, female specimens only.

Tusks yellowish brown basally; distal half red-brown. Medium long, upcurved distally. First joint of maxillary palp almost equals

galea-lacinia. Palp equal to twice length of body of maxilla. Middle tail white. Head and dorsum of thorax light yellow-brown. Legs cream. Abdominal tergites cream-white marked with purplish grey. Ventrally cream-white, with purplish ganglionic streak on sternites 7-9. Gills dark purple-grey in center, fringes lighter purple-grey. Body medium stout. Claws long and slender; not swollen at base.

Distribution: Florida—Gainesville.

Nymph No. 6.

Frontal process rather conical in male. Tusks yellowish, distal half reddish. Medium long, sharply upcurved distally. First joint of maxillary palp approximately equal to galea-lacinia. Palp less than twice length of body of maxilla. Middle tail creamy white. Outer tails of male dark brown with wide dark purplish-brown joinings. Head of male very dark red-brown, dorsum of thorax lighter red-brown. Head and thorax of female light brown. Abdominal tergites of male yellow with reddish-brown markings; of female, white with lavender-grey markings. Ventral of thorax light tan. Sternites of abdomen creamy white with purplish-black ganglionic streaks on 6-9. Gills light grey-lavender in center, fringes same. Body medium slender. Claws rather stout, swollen at base; only slightly curved.

Distribution: North Carolina—Tuckaseegee River, at Jackson.

KEY TO ELEVEN SPECIES OF HEXAGENIA NYMPHS.

1. Frontal process angular; first rudimentary gill simple..... *H. recurvata*
Frontal process not angular; first rudimentary gill bifid..... 2
2. Frontal process square-cut or truncate..... *H. atrocaudata*
Frontal process not truncate..... 3
3. Frontal process conical..... 4
Frontal process dome-shaped or rounded..... 6
4. Body of female exceeding 30 mm. in length; body of male 23 mm. or longer..... *H. carolina*
Body of female less than 30 mm.; of male, less than 23 mm..... 5
5. Tails of male longer than those of female; outer tails and body red-brown..... *H. bilineata*
Tails of male not exceeding those of female; tails and body creamy white..... *Nymph No. 2*
6. Third claw short and stout, much swollen at base..... 7
Third claw long and slender, little if any swollen at base..... 8
7. Tarsus as wide as greatest width of claw; abdomen of male white, outer tails light grey..... *Nymph No. 1*
Tarsus narrower than greatest width of claw; male abdomen yellow, outer tails dark brown..... *Nymph No. 6*
8. Outer tails of male ringed at joinings with darker color..... *H. mingo*
Outer tails of male not ringed at joinings with darker color..... 9
9. Body of female exceeding 25 mm. in length..... 10
Body of female less than 25 mm. in length..... *Nymph No. 4*
10. Abdominal tergites purplish brown with cream markings; palp less than twice body of maxilla..... *Nymph No. 3*
Abdominal tergites white with purplish grey markings; palp equal in length to twice body of maxilla..... *Nymph No. 5*

TABULATION OF CHARACTERS OF NYMPHS.

Species	Body of Male	Body of Female	Outer Tail Male	Outer Tail Female	Hd. vs. Tusk, Male	Hd. vs. Tusk, Female	*Frontal Process	Outer Tail
<i>atrocaudata</i>	23-28	27-35	9-11	9-11	2 $\frac{1}{2}$: 2 $\frac{1}{2}$	2 $\frac{1}{4}$: 3 $\frac{1}{2}$	square	yellow
<i>bilineata</i>	15-22	21-26	9-11	7-8 $\frac{1}{2}$	2 : 3	2 $\frac{1}{2}$: 3 $\frac{1}{2}$	conical	light red-brown
<i>carolina</i>	23-28	32-36	8-12	11-14	2 : 4	3 : 5	dome	yellow
<i>mingo</i>	16 $\frac{1}{4}$ -21 $\frac{1}{2}$	25-27	8-10	9	2 : 2 $\frac{1}{2}$	3 : 3 $\frac{1}{2}$	dome	white
<i>recurvata</i>	20-25	25-29	11-13	12-14	2 : 2	2 $\frac{1}{2}$: 2 $\frac{1}{2}$	angular	purple-brown
No. 1	21-21 $\frac{1}{2}$	27-32	9	10-11	2 : 2 $\frac{1}{2}$	3 : 4	dome	♂ light grey ♀ yellow
No. 2*	17-19	18-21	5 $\frac{1}{2}$	5 $\frac{1}{2}$	1 $\frac{3}{4}$: 2 $\frac{1}{4}$	1 $\frac{1}{2}$: 2	conical	white
No. 3	20	27	7	9-10	2 : 3	3 : 3	dome	yellow
No. 4	16*	17-19 $\frac{1}{2}$	7	6-8	1 $\frac{1}{2}$: 2 $\frac{1}{2}$	2 : 3	dome	white
No. 5		27		9		2 : 2 $\frac{1}{2}$	dome	white
No. 6	18-22 $\frac{1}{2}$	*25-26	6 $\frac{1}{2}$ -8	7-8	2 : 2 $\frac{1}{2}$	2 : 3	dome	♂ brown ♀ white

EXPLANATION OF TABULATION:

All measurements given in millimeters. Blank spaces mean no specimens. For shape of frontal process, see figures. * = specimens not yet fully mature.

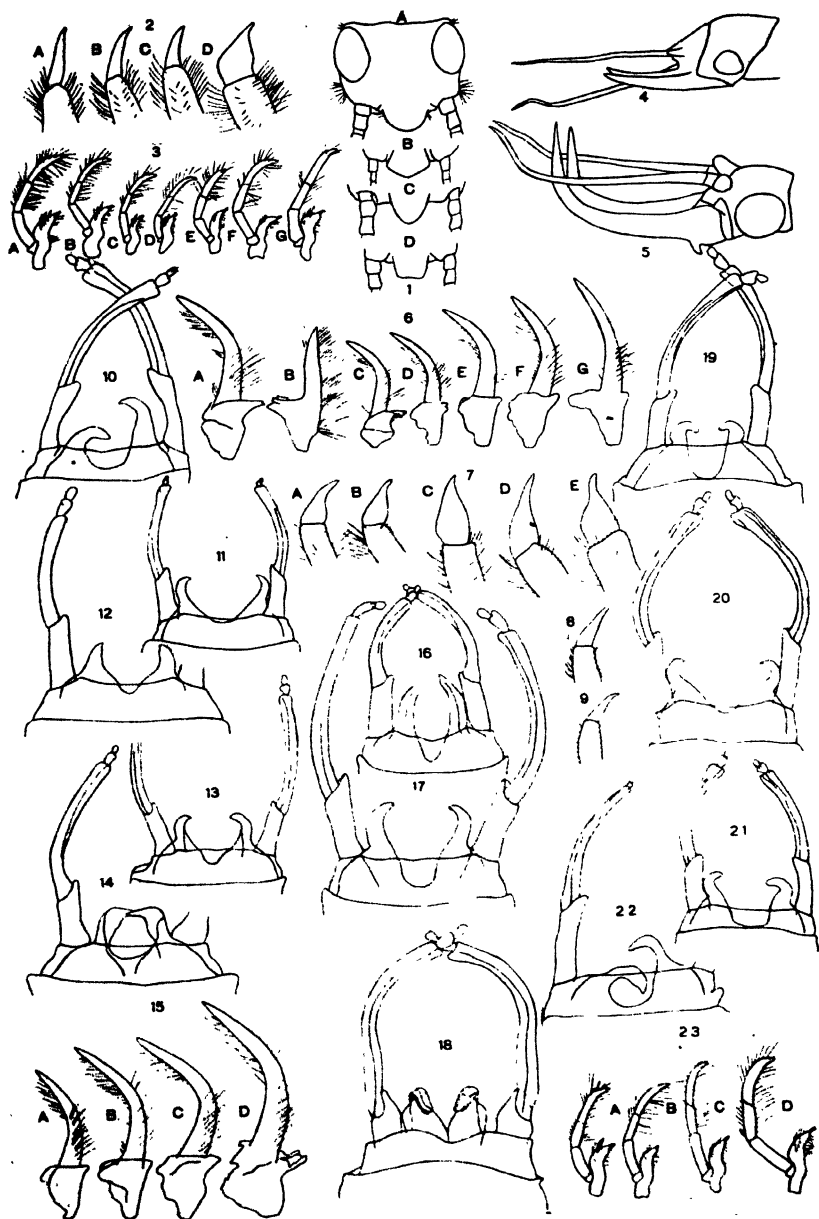
SELECTED BIBLIOGRAPHY.

- Eaton, A. E. 1883-86. A revisional monograph of recent Ephemeridae or mayflies. Trans. Linn. Soc. London. Sec. Series, Zool., Vol. 3; pgs. 50-58, Pl. VII.
- McDunnough, J. 1924. New Canadian Ephemerida with notes. II. Canad. Ent. 56; pgs. 90-93, Pl. I, Figs. 2 and 3.
- McDunnough, J. 1927. Notes on the species of the genus *Hexagenia* with description of a new species (Ephemeroptera). Canad. Ent. 59; pgs. 116-120, Fig. 1.
- Morgan, Anna H. 1913. A contribution to the biology of mayflies. Ann. Ent. Soc. America 6; pgs. 371-413, Text Fig. 3, Pl. XLIX.
- Needham, J. G. 1920. Burrowing mayflies of our larger lakes and streams. Bull. U. S. Bur. Fisheries 36; pgs. 269-292, Pls. LXXI, LXXII, LXXXI.
- Ulmer, G. 1921. Über einige Ephemeropteren-Typen alterer Autoren. Arch. f. Natg. A-6, 87; pgs. 233-239, Text Figs. 4-7.

EXPLANATION OF PLATE.

GENUS HEXAGENIA.

- Fig. 1. Frontal processes of heads of female nymphs. a—*H. mingo*. b—*H. recurvata*. c—*H. carolina*. d—*H. atrocaudata*.
- Fig. 2. Third claws of nymphs. a—Nymph No. 5. b—Nymph No. 4. c—Nymph No. 3. d—Nymph No. 1.
- Fig. 3. Maxillæ of female nymphs. a—Nymph No. 1. b—*H. recurvata*. c—Nymph No. 2. d—Nymph No. 4. e—*H. bilineata*. f—Nymph No. 6. g—Nymph No. 3.
- Fig. 4. Head of nymph, *H. recurvata*.
- Fig. 5. Head of nymph, *H. carolina*.
- Fig. 6. Mandibular tusks of female nymphs. a—Nymph No. 1. b—*H. recurvata*. c—Nymph No. 2. d—Nymph No. 4. e—*H. bilineata*. f—Nymph No. 6. g—Nymph No. 3.
- Fig. 7. Third claws of nymphs. a—*H. mingo*. b—Nymph No. 6. c—*H. atrocaudata*. d—*H. recurvata*. e—*H. carolina*.
- Fig. 8. Third claw of *H. bilineata*.
- Fig. 9. Third claw of Nymph No. 2.
- Fig. 10. Male genitalia, *H. rosacea*.
- Fig. 11. Male genitalia, *H. elegans*.
- Fig. 12. Male genitalia, *H. atrocaudata*.
- Fig. 13. Male genitalia, *H. orlando*.
- Fig. 14. Male genitalia, *H. bilineata*.
- Fig. 15. Mandibular tusks of female nymphs. a—*H. mingo*. b—Nymph No. 5. c—*H. atrocaudata*. d—*H. carolina*.
- Fig. 16. Male genitalia, *H. rigida*.
- Fig. 17. Male genitalia, *H. weewa*.
- Fig. 18. Male genitalia, *H. recurvata*.
- Fig. 19. Male genitalia, *H. limbata*.
- Fig. 20. Male genitalia, *H. carolina*.
- Fig. 21. Male genitalia, *H. mingo*.
- Fig. 22. Male genitalia, *H. marilandica*.
- Fig. 23. Maxillæ of female nymphs. a—*H. mingo*. b—Nymph No. 5. c—*H. atrocaudata*. d—*H. carolina*.



NEW SPECIES OF CRANE FLIES FROM SOUTH AMERICA. PART V.*†

(Family Tipulidæ, Order Diptera.)

CHARLES P. ALEXANDER,
Amherst, Massachusetts.

The majority of the species herein described as new were collected in *Colombia* by Mr. Fred W. Walker, chiefly at Vista Nieve on Mount Santa Marta. All such resulting types have been returned to the Museum of Zoology of the University of Michigan. One additional species was likewise taken on Mount Santa Marta by my friend, Dr. George Salt. The other species considered are from *Brazil*, collected by the veteran naturalist, Mr. Friedrich Schade, and from *Chile*, where they were taken in the Province of Malleco by Professor D. S. Bullock. Except where indicated above, the types of the novelties are preserved in my own collection. I wish to thank the gentlemen above mentioned very sincerely for this appreciated co-operation in making known the rich Tipulid fauna of the Neotropics.

Macromastix Osten Sacken.

Macromastix (Araucomyia) bullocki sp. n.

General coloration shiny yellow, the praescutum with reddish stripes; antennae of both sexes very short, 10-segmented; femora brownish yellow, the tips narrowly brownish black; wings grayish subhyaline, the stigma and a confluent seam on the anterior cord dark brown; abdomen yellow, lined longitudinally with black, the latter areas very extensive on the sternites.

Male.—Length, about 11 mm.; wing, 12 mm.

Female.—Length, about 15 mm.; wing, 14-14.5 mm.

Frontal prolongation of head obscure yellow, darker on sides, the nasus elongate; palpi black. Antennæ 10-segmented, unusually short in both sexes, a little longer than the head, excluding the frontal prolongation; first scapal segment brownish-yellow, the second clearer

*Contribution from the Entomological Laboratory, Massachusetts State College.

†The preceding part under this general title was published in these ANNALS in 1930 (XXIII: 721-740).

yellow; flagellum black; flagellar segments elongate-cylindrical, the verticils of the basal segments short, on the outer segments becoming more elongate, exceeding the segments. Head pale brown above, the posterior orbits clear yellow.

Pronotum light yellow, restrictedly infuscated medially. Mesonotal praescutum nitidous, deep yellow, with four narrow dark reddish stripes, the intermediate pair blackened on their anterior portions; median region of scutum yellow, the lobes more reddish; scutellum yellowish-testaceous; postnotal mediotergite yellow with two reddish brown longitudinal areas. Pleura nitidous, yellow, variegated with reddish areas. Halteres pale, the knobs infuscated. Legs with the fore coxæ yellow, lined with reddish, the other coxæ darker; trochanters brownish yellow; femora brownish yellow, the tips narrowly brownish black; tibiæ and tarsi obscure yellow, the latter passing into dark brown; claws (σ) with a basal tooth. Wings grayish subhyaline, cells *C* and *Sc* more yellowish; stigma and a connecting cloud on the anterior cord dark brown; wing-tip vaguely infumed; a dark seam in cell *M* along vein *Cu*; veins black, more yellowish in the costal region. Macrotrichia of veins small and inconspicuous. Venation: R_{1+2} diverging strongly from R_3 , paralleling the free tip of Sc_2 ; cell M_1 with the petiole longer to shorter than *m*.

Abdominal tergites obscure yellow, with a narrow median black vitta; sternites similar, trivittate with black, the median stripe very wide, restricting the ground-color to narrow sublateral lines; hypopygium obscure yellow. Male hypopygium with the lateral lobes of the tergite very long and slender, separated by a deep notch; the fused basistyles and sternites similarly long and slender. Ovipositor with all valves very long and slender, straight.

HABITAT: Chile. *Holotype*, σ , Nahuelbuta, near Angol, Malleco, among Chilean Pines, *Araucaria imbricata* Pav., altitude 800 meters, March 9, 1929 (D. S. Bullock). *Allotopotype*, η , altitude 1,200 meters, March 10, 1929. *Paratopotype*, a teneral η , with the allotype.

Macromastix (*Araucomyia*) *bullocki* is named in honor of the collector, Professor Dillman S. Bullock. The species is very different from *M. (A.) paulseni* (Phil.) in the short antennae of the male and all details of coloration and structure. The polished yellow and rusty coloration of the thorax is very suggestive of certain species of *Nephrotoma*.

Tipula Linnaeus.

Tipula laterosetosa sp. n.

Ground-color of mesonotum obscure yellow, the praescutum with four brown stripes that are narrowly bordered by darker brown; antennae short in both sexes, the flagellum bicolorous;

pleura variegated yellow and brown; femora with a broad yellowish white subterminal ring; tibiae brown, the bases narrowly pale yellow; wings grayish brown, variegated by dark brown and cream-yellow areas, the latter including a W-shaped mark across the outer ends of cells *R* and *M*, and a series of small marginal spots in the medial to anal fields; male hypopygium with a lateral pencil of yellow setae on either side of tergite; ninth sternite bearing two approximated cylindrical lobes on the mid-line.

Male.—Length, about 21 mm.; wing, 21.5 mm.

Female.—Length, about 25 mm.; wing, 24 mm.

Frontal prolongation of head brownish yellow, the nasus elongate, concolorous; palpi brownish black. Antennae relatively short in both sexes; scape yellow; flagellar segments bicolorous, the basal enlargement brownish black, the remainder yellow; on outer segments the coloration becomes more brownish yellow; verticils much longer than the segments. Head buffy-yellow, on the posterior vertex trivittate with slightly darker brown, including a median vitta and a similar line on the posterior orbits; median region of anterior vertex produced into a small rounded papilla.

Mesonotal praescutum obscure yellow, with four light brown stripes that are narrowly bordered by dark brown; humeral region yellow, enclosing a small black marginal spot; posterior inter-spaces appearing as elongate pale yellow triangles; a shallow crescent-shaped brown area at suture; scutal lobes with centers brownish testaceous, encircled with dark brown, the median area testaceous, variegated by brown behind; scutellum dark brown, the parascutella similar, with a pale central spot; postnotal medio-tergite gray, with a capillary brown median line that becomes more expanded on the caudal margin. Pleura light yellow, variegated by transverse brown areas on sternopleurite and anepisternum, the latter broader and forming part of a more or less interrupted longitudinal stripe extending from the cervical sclerites to the postnotum; a small velvety-black spot on the dorsal pteropleurite; pleurotergite dark brown, the elevated ventral portion densely set with golden-yellow tomentum. Halteres dusky, the base yellow, the knobs obscure yellow. Legs with the coxae and trochanters yellow; femora yellow basally, passing into black on the distal half, this darkening enclosing a pale yellow subterminal ring; tibiae with the extreme bases yellow, the remainder dark brown; tarsi dark reddish brown. Wings with the ground-color grayish brown, variegated with dark brown and cream-colored areas; prearcular region chiefly darkened, separated from a more extensive post-arcular area by clear yellow at arculus; no dark spots along cell *Sc*, as usual in the *glaphyoptera* group; stigma darkened; small dark areas along cord and at near mid-length of vein *Cu*; the chief creamy areas appear as a W-shaped mark lying transversely across cells *C*, *Sc*, *R* and *M* before the cord; the distal fourth of cell *R*; a narrow, irregular line beyond the stigma; small

marginal spots in outer ends of cells 2nd M_2 , M_3 , M_4 and 1st A , there being two in the last-named cell; and extensive area in basal half of cell Cu , extending into cell M ; veins dark, pale in the creamy areas. Venation: R_{1+2} entire; R_{4+5} usually sinuous, deflected caudad on outer half, cell R_3 at margin being unusually wide.

Abdominal tergites chiefly blackened, the incisures of the basal segments more cinnamon-brown; outer segments margined laterally with cinnamon-brown; basal sternites reddish brown, segment four chiefly darkened; outer segments darkened, except at margins. Male hypopygium relatively large, the tergite fused with the sternite. Tergite with the median region produced into a depressed lobe, its apex with a shallow V-shaped notch; extreme margin narrowly chitinized and produced at lateral angles into small ventral spines; lateral region of tergite bearing a tuft of long yellow setæ. Region of basistyle not differentiated from sternite except by a short straight suture below; apex of basistyle truncated. What appears to be a curiously modified outer dististyle is borne at end of basistyle, appearing as a pale membranous lobe that is prolonged ventrad into a ribbon-like extension. Ninth sternite bearing two conspicuous subcylindrical lobes, closely applied to one another to appear almost as a single structure. Ovipositor with all valves well-developed, the tergal valves hairy except on distal third; sternal valves compressed, yellow.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 8, 1926 (F. W. Walker). *Allotopotype*, ♀, August 6, 1926. *Paratopotype*, a damaged ♂, August 7, 1926.

The general resemblance of this fly to various species of the *oblique-fasciata* group is probably superficial only. The species is well-distinguished by the peculiar structure of the male hypopygium.

Limonia Meigen.

Limonia (*Rhipidia*) *tripectinata* sp. n.

Belongs to the *maculata* group; allied to *inaequipectinata*; antennae (♂) elongate; flagellar segments 2 to 11 unequally tripectinate, there being a very small median spur, in addition to the elongate branches; wings with four darkened clouds in the subcostal field, in addition to the stigma; male hypopygium with the rostral prolongation of the ventral dististyle long and slender, with two spines that arise close together.

Male.—Length, about 6 mm.; wing, 7 mm.

Female.—Length, about 7.5-8 mm.; wing, 7.5.

Rostrum and palpi black. Antennæ (♂) very large and conspicuous, if bent backward extending to some distance beyond the base of

abdomen; scape black, the flagellar segments white, the basal swelling and all branches black; terminal segment entirely black; branches very long and slender, the longest approximately one-third the length of the entire organ; in addition to the long branches, there arises between them a small spur, forming a very unequal third branch; branch of first flagellar segment single; segments 2 to 11 unequally tripectinate, as described, the branches of outer segments gradually decreasing in length; terminal segment elongate, a trifle shorter than the branches of the penultimate segment. Antennæ (♀) nearly simple, the flagellar segments with very short, inconspicuous apical pedicels; terminal segment elongate. Head dark gray.

Pronotum black. Mesonotal praescutum reddish brown, the color broadened behind, the lateral and humeral regions extensively more yellowish; median region of praescutum narrowly darker brown; scutum reddish brown; scutellum darker brown, paler medially; postnotum dark brown. Pleura pale grayish brown, with two vague darker longitudinal stripes, the more dorsal stripe ending at the pteropleurite, the ventral stripe extending from the fore coxæ to the base of abdomen. Halteres pale yellow, the knobs weakly infuscated. Legs with the coxæ yellow, darkened basally; trochanters yellow; femora yellow, narrowly and vaguely darkened subapically; tibiæ brownish yellow; tarsi passing into darker brown. Wings with the ground-color creamy, with a restricted dark pattern, this consisting of four diffuse dark clouds in the subcostal field, in addition to the stigma; restricted pale brown seams along cord and outer end of cell *1st M*₂; wing-tip, especially in the outer ends of the radial cells, darkened; veins yellow, darker in the clouded areas. Venation, *Sc* long, *Sc*₁ ending about opposite two-thirds the length of *Rs*, *Sc*₂ at its tip; *Rs* gently arcuated at origin; free tip of *Sc*₂ and *R*₂ in approximate transverse alignment; *m-cu* at fork of *M*.

Abdominal segments obscure yellow, the caudal margins conspicuously ringed with dark brown; hypopygium obscure yellow. Male hypopygium with the tergite transverse, the caudal margin convex, the median region transverse or feebly concave. Basistyle moderately large, the ventro-mesal lobe stout basally, narrowed to an obtuse point that bears a single long powerful seta. Ventral dististyle of moderate size, a little larger than the basistyle; rostral prolongation long and slender, at about two-thirds the length bearing two long slender spines that are placed close together. Dorsal dististyle elongate, curved and narrowed to a long acute apical point. Gonapophysis with the mesal-apical lobe blackened, obliquely obtuse at tip, separated from the shorter outer lobe by a narrow U-shaped notch.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 7, 1926 (F. W. Walker). *Allotopotype*, ♀, August 7, 1926. *Paratopotypes*, 3 ♂♂, 10 ♀♀, August 6-8, 1926.

Limonia (Rhipidia) tripectinata has an antennal structure that is much like that of *L. (R.) inæquipectinata* Alexander, which differs conspicuously in the smaller antennae, the wing-pattern and venation, and in the structure of the male hypopygium.

Limonia (Rhipidia) mystica sp. n.

Belongs to the *uniseriata* group; general coloration yellow, the mesonotal praescutum with a broad, median brown stripe; antennae entirely black; flagellar segments 1 to 10 with a single branch; thoracic pleura yellow, with two narrow black stripes; halteres black; wings whitish, with a conspicuous brown and gray clouded pattern; cell M_2 tending to be open by atrophy of the basal section of M_3 ; male hypopygium with the spines of the rostral prolongation of the ventral dististyle short and spike-like.

Male.—Length, about 5 mm.; wing, 6 mm.

Rostrum and palpi black, the former about as long as the remainder of head. Antennæ black; basal flagellar segments with a single branch, the formula being 2+10+2; longest branch (about flagellar segments 7 to 9) approximately three times the segment; basal flagellar segment with a stout basal branch that is shorter than the segment; penultimate segment simple, or nearly so; terminal segment elongate, narrowed outwardly. Head black, sparsely pruinose.

Pronotum yellow, narrowly dark brown medially. Mesonotal praescutum buffy yellow, with a broad dark brown median stripe that is a trifle expanded laterally at near midlength; lateral stripes lacking or represented only by a small circular dusky cloud at the suture; scutum yellow, each lobe with a triangular brown area, the point directed caudad onto the scutellum; scutellum yellowish testaceous; postnotal mediotergite chiefly dark brown, pale yellow laterally. Pleura yellow, with two narrow black longitudinal stripes, the dorsal one extending from the cervical sclerites across the dorsal pleurites to the halteres; ventral stripe less distinct and more broken, including the dorsal sternopleurite and the meral region. Halteres short, black, the extreme base of the stem yellow, the knobs large. Legs with the coxæ yellow, slightly darkened across their bases; trochanters yellow; femora brownish yellow, vaguely darkened outwardly; tibiæ and tarsi pale brown, the terminal tarsal segments blackened; posterior legs lost. Wings whitish, more cream-colored in the costal region, with a heavy brown costal pattern and abundant gray clouds that cover most of the remainder of the wing; dark clouds six in number, the first two confluent or nearly so; fourth area at origin of R_s ; fifth at fork of Sc , the sixth at stigma; the gray clouds include the cord and a more or less complete subapical fascia; medial, cubital and anal cells more evenly clouded with gray; the ground-color appears at the outer

end of cell *M*, bases of Anal cells and as a smaller area in cell 1st *A* at end of vein 2nd *A*; veins cream-yellow in the ground-areas, more infuscated elsewhere. Venation: *Sc*₁ ending about opposite three-fifths the length of *Rs*, *Sc*₂ at its tip; *Rs* long, gently arcuated; *R*₂ faint, subequal to the free tip of *Sc*₂; cell *M*₂ open or tending to be open by the atrophy of the basal section of *M*₂; *m-cu* close to fork of *M*. In one wing of the type, the basal section of *M*₂ is entirely atrophied; in the other wing, it is indicated by a vague trace.

Abdominal tergites yellowish brown, the caudal margins narrowly blackened; sternites more uniformly yellow; hypopygium brownish yellow. Male hypopygium with the tergite transverse, its caudal margin straight or very gently concave. Basistyle small, with a large ventro-mesal lobe. Ventral dististyle considerably larger than the basistyle, the rostral prolongation slender, with two small spike-like spines at near midlength, these placed close together. Dorsal dististyle a slightly curved darkened rod, slightly dilated outwardly, the tip suddenly narrowed to a slender point. Gonapophyses with the mesal apical lobe darkened, the outer margin roughened, the apex a more slender blackened point.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 7, 1926 (F. W. Walker).

The closest relative of the present species is *L. (R.) pallatangæ* Alexander (Ecuador), which differs in the larger size, details of coloration of the antennae, body and wings, and the much shorter flagellar branches.

Gynoplistia Westwood.

Gynoplistia (*Gynoplistia*) *variata* sp. n.

Generally similar and most nearly allied to *G. (G.) manicata* Alexander (Chile), differing most conspicuously in the smaller size and absence of blackened femoral tips.

Male.—Length, about 17-18 mm.; wing, 14.5-15 mm.

Antennæ (♂) 18-segmented, the formula being 2+2+8+6; scape and apices of flagellar segments yellow, the branches and basal enlargements of the segments darkened, the outer segments more uniformly darkened; longest branch (about flagellar segment 7 or 8) about five times the segment and shorter than the combined length of the simple terminal flagellar segments; last branch shorter than to approximately twice the length of the segment. Head brown.

Mesonotum brown, with a yellowish pollen, the praescutal stripes only feebly indicated. Pleura chiefly covered by a silvery-yellow bloom, the ventral sternopleurite more glabrous. Halteres pale, the knobs infuscated. Legs with the femora brownish yellow, the tips weakly darkened but not at all blackened, as in *manicata*; tibiae yellow, the tips more narrowly darkened. Wings pale yellow, the stigma a

very little darker; in the holotype with a few grayish brown blotches in cells *M* and *Cu* near the cord and larger ones in the ends of the Anal cells, including a larger area in cell 1st *A* that almost crosses the cell. Venation: Much as in *manicata*, with the anterior branch of *Rs* similarly long and sinuous; *Rs* a little shorter; cell 1st *M*₂ slightly narrower, especially on the basal half.

Abdominal tergites grayish brown, the basal sternites bilineate with black; hypopygium yellowish brown. Male hypopygium with the outer dististyle much as in *manicata*. Interbases appearing as nearly simple chitinized horns, with a microscopic point on margin at near midlength.

HABITAT: Chile. *Holotype*, ♂, Angol, Malleco, November 25, 1929 (D. S. Bullock). *Paratopotype*, ♂, April 30, 1929.

***Gynoplistia* (*Gynoplistia*) *biarmata* sp. n.**

Generally similar and allied to *G. (G.) manicata* Alexander, differing especially in the absence of black femoral tips and the structure of the male hypopygium, especially of the interbasal processes.

Male.—Length, about 23 mm.; wing, 19 mm.

Antennæ 19-segmented, the formula being 2+2+9+6; black, the incisures of the basal flagellar segment restrictedly yellow; tips of flagellar branches paler than their bases; longest branch shorter than the combined terminal simple segments; last branch about one-half longer than the segment; terminal segment constricted, as in the group. Head gray.

Mesonotum gray, the praescutum with three brown stripes, the median stripe darker in front, weakly divided behind; pseudosutural foveæ bicolorous, reddish with the lateral portion blackened; median region of scutum and the scutellum light gray; postnotal mediotergite yellowish brown, sparsely pruinose. Pleura heavily pruinose. Halteres pale yellow, the knobs weakly infuscated. Legs with the femora dark brown, yellow basally; tibiæ abruptly yellow, with narrowly darkened tips; tarsi yellow, the outer segments a little darkened. Wings pale yellow, the oval stigma pale brown; a small brown cloud at end of vein *R*₂; veins brown, more yellowish in the costal region. Venation as in *manicata* and allies.

Abdomen black, pruinose, the segments very narrowly margined laterally and caudally with yellow; hypopygium chiefly dark. Male hypopygium as in *manicata* and allies, but the interbasal processes very different in form, broad-based, with two large spines, the more basal larger and bearing a microscopic spinule on outer margin at near midlength.

HABITAT: Chile. *Holotype*, ♂, Angol, Malleco, 1928 (D. S. Bullock).

The two species described above, *Gynoplistia* (*Gynoplistia*) *variata* sp. n. and *G. (G.) biarmata* sp. n., together with *G. (G.) gilvipennis* Alexander and *G. (G.) manicata* Alexander, and very possibly also *G. (G.) flavipennis* (Philippi), form a compact group of large *Gynoplistiæ* in which the anterior branch of *Rs* is long and conspicuously sinuous and the tibial spurs and tarsal claws of both sexes are microscopically toothed.

Eriocera Macquart.

Eriocera tholopa sp. n.

General coloration black, heavily pruinose; antennae short in both sexes; head dull orange, darkened behind; mesonotal praescutum with three shiny black stripes, the lateral margins pruinose, the interspaces more yellowish pollinose; legs and halteres black; wings dusky, the cord seamed with darker; *R*₂ at or before the fork of *R*₄₊₅; cell *M*₁ lacking; *m-cu* at fork of *M*; ovipositor very long and slender.

Male.—Length, about 9 mm.; wing, 7 mm.

Female.—Length, about 12 mm.; wing, 8.5 mm.

Rostrum and palpi black. Antennae black throughout, short in both sexes, 7-segmented (♂), 9-segmented (♀); first flagellar segment nearly as long as remainder of flagellum. Head dull orange, the occiput infuscated; vertical tubercle weakly bifid.

Mesonotal praescutum with three shiny black stripes, the lateral margins pruinose, the interspaces more yellowish pollinose; posterior sclerites of mesonotum black, sparsely pruinose, the scutellum and postnotum more heavily so. Pleura black, heavily pruinose, the dorso-pleural region slightly more buffy. Halteres black; the extreme base of stem paler. Legs with the coxæ pruinose; trochanters black; femora black, the extreme bases more reddish brown; tibiae brownish black to black; tarsi black. Wings dusky, the costal region darker, the wing-base somewhat more yellowish brown; narrow darker brown seams along cord and veins *Rs* and *R*₅; veins black. Venation: *Sc*₁ ending opposite the fork of *Rs*, *Sc*₂ at its tip; *Rs* elongate, weakly angulated at origin; *R*₂ at or just before the fork of *R*₄₊₅ (♂) or more than its own length before this fork (♀); cell *M*₁ lacking; *m-cu* at or beyond the fork of *M*, longer than the distal section of *Cu*₁.

Abdomen black, gray pruinose, more heavily so on the basal portions of the segments; male hypopygium black. Ovipositor with the tergal valves exceedingly long and slender, horn-yellow, blackened at bases.

HABITAT: Brazil. *Holotype*, ♂, Jaragua, Santa Catharina, October 10, 1929 (F. Schade). *Allotopotype*, ♀, October 9, 1929.

Eriocera tholopa is apparently closest to *E. flaviceps* (Wied.), differing in the coloration of the body and wings. The latter species is still known to me only from the very brief and insufficient original description

Elephantomyia Osten Sacken.

Elephantomyia (Elephantomyia) humilis sp. n.

Size small (wing, not exceeding 6.5 mm.); thorax entirely yellow, immaculate; legs pale brown; wings yellowish subhyaline.

Male.—Length, excluding rostrum, about 5.5 mm.; wing, 5.8 mm.; rostrum, about 6 mm.

Female.—Length, excluding rostrum, about 6.5 mm.; wing, 6.5 mm.; rostrum, about 5 mm.

Rostrum elongate, subequal to or longer than the body, dark brown, including the palpi. Antennæ dark brown, the verticils very long and conspicuous, much exceeding the segments in both sexes. Head very light gray.

Thorax entirely yellow, unmarked. Halteres pale, the knobs weakly infuscated. Legs with the coxæ and trochanters yellow, the fore coxæ slightly infuscated on outer face; remainder of legs pale brown; a weak tibial spur on hind legs of male, not developed on other legs, at least of female. Wings yellowish subhyaline, a little darker toward apex; stigma long-oval, brown; veins brown, those of basal half of wing somewhat more yellowish brown. Venation: Sc_2 ending shortly before the fork of R_s , Sc_1 atrophied or nearly so; R_s long, gently arcuated to feebly angulated; branches of R_s long, extending generally parallel for their entire length; cell 1st M_2 short-rectangular, shorter than any of the veins beyond it; $m-cu$ subequal to or longer than the distal section of Cu_1 , at or before midlength of cell 1st M_2 ; cell 2nd A long and narrow.

Abdomen yellowish brown, the sternites somewhat paler; in the female, the basal tergites are weakly bicolorous, the proximal half being somewhat darker than the remainder; on the outer segments the color is more uniform brown. Male hypopygium with the mesal face of the basistyle densely cushioned. Outer dististyle unusually short and stout, broad-based, shorter than the strongly curved inner dististyle.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker). *Allotopotype*, ♀, August 6, 1926. *Paratopotype*, ♂, with the allotype.

Elephantomyia humilis is even smaller than *E. boliviensis* Alexander, differing from the latter in the details of body-coloration and wing-venation, such as the straighter anterior

branch of *Rs*, small cell *1st M*₂ and more elongate vein *2nd A*. The paratype is very small and has lost the head, but seems undoubtedly to represent the same species.

Elephantomyia (Elephantomyia) angustissima sp. n.

General coloration yellow; pronotum and praescutum with a brown median stripe; femora obscure yellow, the tips narrowly blackened, preceded by a wide clearer yellow annulus; male hypopygium with the inner dististyle relatively elongate, a trifle longer than the outer style.

Male.—Length, excluding rostrum, about 8 mm.; wing, 8.5 mm.; rostrum, about 8 mm.

Female.—Length, excluding rostrum, about 9 mm.; wing, 8 mm.; rostrum, about 8 mm.

Rostrum nearly as long as the body in both sexes, dark brown. Antennæ with the scapal segments dark brown, the flagellum paler; flagellar segments becoming more slender and attenuate outwardly. Head yellowish gray, the center of the posterior vertex more infuscated; anterior vertex reduced to a strip that is a little narrower than the diameter of the first scapal segment.

Pronotum and mesonotum yellow, the anterior portion with a dark brown median stripe that becomes obsolete at near midlength of the praescutum. Pleura yellow. Halteres pale, the knobs weakly infuscated, the extreme base of the stem yellow. Legs with the coxæ and trochanters yellow; femora obscure yellow, the extreme tips blackened, preceded by a wider, more diffuse, clearer yellow ring; tibiæ and tarsi yellowish brown to pale brown; tibial spurs present. Wings with a yellowish tinge, the apex more darkened, cells *C* and *Sc* a little more suffused; stigma oval, dark brown; veins dark brown. Venation: *Sc*₁ ending about opposite the fork of *Rs*, *Sc*₂ at its tip; *Rs* relatively short, weakly angulated at origin; branches of *Rs* extending nearly parallel to one another for their entire length, the upper branch a little sinuous beneath the stigma; *m-cu* at near midlength of cell *1st M*₂, exceeding the distal section of *Cu*₁.

Abdominal tergites brownish yellow, with a more or less continuous brown median line, more expanded on the caudal margins of the segments; subterminal segments more uniformly darkened; sternites yellow, the caudal margins of the segments narrowly darkened. Male hypopygium with the mesal face of the basistyle with relatively few but long and conspicuous, erect setæ. Outer dististyle relatively elongate, bifid at apex. Inner dististyle only a trifle longer than the outer, nearly straight. Gonapophyses appearing as long, slender, sinuous spines. Aedeagus a penefilum of moderate length and stoutness.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude 5,000 feet, August 6, 1926 (F. W. Walker). *Allotopotype*, ♀.

Elephantomyia angustissima is distinct from all described regional species in the pattern of the legs and structure of the male hypopygium. It is closest to *E. westwoodi* O. S. of the Nearctic fauna, differing especially in the details of structure of the hypopygium, especially of the gonapophyses.

Teucholabis Osten Sacken.

Teucholabis (Teucholabis) marticola sp. n.

General coloration black; mesonotal praescutum yellow, with three nearly confluent blackish stripes; scutellum yellow; knobs of halteres infuscated; femora yellow, the tips blackened; wings subhyaline, the small stigma pale brown; male hypopygium with the apical spine of the basistyle very reduced; outer dististyle simple, terminating in an acute blackened spine.

Male.—Length, about 4.5 mm.; wing, 4 mm.

Rostrum black, nearly as long as the remainder of head; palpi black. Antennæ black throughout; flagellar segments oval, decreasing in size outwardly. Head black, sparsely pruinose.

Pronotum obscure yellow, narrowly blackened laterally. Mesonotal praescutum shiny yellow, the disk chiefly covered by three blackish brown stripes that are nearly confluent, the median stripe paler than the laterals; scutal lobes blackened, the median region obscure yellow; scutellum pale yellow; postnotal mediotergite dark reddish brown. Pleura chiefly black, the ventral sternopleurite and meral region more reddish. Halteres pale, the knobs infuscated. Legs with the coxæ reddish brown, the trochanters more yellowish; femora yellow, the tips broadly blackened, the amount nearly equal on all legs; tibiæ yellowish brown, darker apically; tarsi broken. Wings subhyaline, the small, subcircular stigma pale brown; veins pale brown. Venation: Sc_1 ending about opposite one-third the length of the long arcuated Rs , Sc_2 opposite the origin of the latter; R_2 lying just beyond the level of the basal section of R_5 ; R_{1+2} short, the tip subobsolete; cell 1st M_2 long, widened outwardly, m longer and more arcuated than the basal section of M_3 .

Abdominal tergites dark brown, the caudal margins of the segments narrowly pale; sternites more uniformly pale; hypopygium yellowish. Sternal pocket relatively simple. Male hypopygium with the basistyle short, the apical spine very tiny. Outer dististyle a simple slender rod that narrows to a slender smooth blackened spine. Inner dististyle small, very strongly curved, the tip blackened, narrowed to a slightly decurved point.

HABITAT: Colombia. *Holotype*, ♂, Mt. Santa Marta, November 1, 1926, at light (G. Salt).

By means of my key to the American species of *Teucholabis* (Trans. Amer. Ent. Soc., 40: 235–239; 1914), *Teucholabis*

marticola runs to couplet 24, disagreeing with both included species, *tristis* Alexander (Peru) and *molesta* Osten Sacken (Mexico), in the coloration of the thoracic dorsum, infuscated halteres, and details of venation.

Gonomyia Meigen.

Gonomyia (*Lipophleps*) *lemniscata* sp. n.

Belongs to the *pleuralis* group; size small (wing, ♂, 3.5 mm.); male hypopygium with the dististyle terminating in a short blackened spine; on outer face of style at near mid-length with a small spike-like spine that is surrounded by numerous erect setae.

Male—Length about 3 mm.; wing, 3.5 mm.

Rostrum and palpi black. Antennae with the scape and basal segments of the flagellum orange-yellow, the remainder of the flagellum brown. Head chiefly pale yellow.

Pronotum and anterior lateral pretergites whitish. Mesonotal praescutum fulvous-brown; scutal lobes similarly colored; median region of scutum and the scutellum more yellowish, with a continuous capillary brown median line; postnotum yellow. Pleura yellow, with two narrow brown longitudinal stripes. Halteres pale, the knobs weakly darkened. Legs with the fore coxae darkened, the remaining coxae yellow; trochanters yellow; femora light brown, darkening to a narrow subterminal ring, the extreme apex again pale; tibiae and tarsi pale brown. Wings with a faint brown tinge, the base and costal region clear yellow; stigma oval, dark brown, as in the group; cells on either side of the cord variegated by pale creamy areas; veins pale, the cord and outer end of cell 1st M_2 darker. Venation: Sc_1 ending a short distance before the origin of R_s , the distance on Costa being a little more than one-half of R_s ; anterior branch of sector pale, strongly curved cephalad around the stigma; veins R_s and M_{1+2} approximated at wing-margin.

Abdominal tergites pale yellow medially, margined caudally and laterally with brown; sternites more uniformly pale, margined caudally with brown. Male hypopygium of the general structure of *recurvata*, differing especially in details of the dististyle. Outer fleshy lobe of basistyle relatively stout; spinous lobe of basistyle pale basally, narrowed to an acute point. Dististyle extended into a short, blackened spine, immediately before this with a small fleshy lobe bearing two fasciculate setae; outer face of style at near midlength bearing a small spike-like spine that is surrounded by numerous erect setae. Gonapophyses of both sets almost as in *recurvata*, the elongate arms delicately fringed with setae along mesal edge; apical lobes of median phallosomic structure pale, elongate, gently divergent.

HABITAT: Colombia, Brazil. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, Colombia, altitude 5,000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker). *Paratype*, ♂, Jaragua, Santa Catharina, Brazil, September 20, 1929 (F. Schade).

Gonomyia (*Lipophleps*) *lemniscata* is allied to *G. (L.) recurvata* Alexander, differing in the details of structure of the male hypopygium, more especially of the dististyle. The occurrence of this species and *Limonia* (*Geranomyia*) *walkeri* Alexander on Mt. Santa Marta and again in Santa Catharina in southeastern Brazil is worthy of note.

***Gonomyia* (*Gonomyia*) *methodica* sp. n.**

Belongs to the *subcinerea* group; general coloration dark brown; antennae black throughout; scutellum light yellow; pleura yellow, the anepisternum more darkened; wings tinged with brown; *Sc* short, *Sc*₁ ending opposite origin of *Rs*, *Sc*₂ at its tip; *R*₂ gently arcuated, not deflected cephalad at outer end; male hypopygium with the outer dististyle a small oval fleshy lobe; phallosome bearing two strongly hooked lateral spines.

Male.—Length about 4.4 mm.; wing, 5.2 mm.

Rostrum and palpi black. Antennæ black throughout; outer flagellar segments becoming long and slender, with relatively long dense verticils. Head dark gray.

Pronotum dark brown. Mesonotal praescutum and scutal lobes dark brown, very sparsely pruinose; anterior lateral pretergites and restricted humeral region very pale yellow; pseudosutural foveæ elongate, black; median region of scutum testaceous-yellow; scutellum light yellow, the base medially with a darkened spot; postnotal mediotergite pale brown, sparsely pruinose, the cephalic-lateral portions restrictedly yellow. Posterior pleura and pleurotergite pale yellow, without clearly defined dark markings, the cephalic pleurites weakly infuscated. Halteres dusky, the extreme base of the stem pale yellow. Legs with the coxæ pale yellow, the fore coxæ slightly more darkened; trochanters pale yellow; remainder of legs dark brown. Wings with a brown tinge, the ill-defined stigma slightly darker brown; veins dark brown. Costal fringe relatively long and conspicuous. Venation: *Sc* short, *Sc*₁ ending just beyond the origin of *Rs*, *Sc*₁ subequal to *Sc*₂; *Rs* relatively short, less than *R*₂₊₃₊₄; *R*₃ gently arcuated, not deflected cephalad at tip, as in allied species; *m-cu* at two-fifths the length of cell 1st *M*₂.

Abdominal tergites dark brown, the sternites pale; hypopygium yellowish brown. Male hypopygium with the basistyle relatively short and stout, the outer lateral lobe longer than either dististyle; a small blunt tuberculate lobe on mesal face of proximal end of basistyle. Outer dististyle a small, oval, fleshy lobe that is densely covered with delicate setulæ and a few long setæ. Inner dististyle a little larger,

produced into a gently curved blackened spine, the margin of which, at near midlength, bears a long seta; apex of style a short blunt lobe bearing several setæ, two of which are larger and fasciculate. Phallosome asymmetrical, large and complex, bearing at near midlength a pale oval lobe; two lateral spines that are strongly interlocked.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 7, 1926 (F. W. Walker).

Gonomyia (*Gonomyia*) *methodica* is readily distinguished from allied regional species by the structure of the male hypopygium.

Neognophomyia Alexander.

Neognophomyia colombicola sp. n.

General coloration of mesonotal praescutum reddish; postnotum blackened; pleura pale yellow, with a conspicuous blackened dorso-longitudinal stripe; wings whitish, with a relatively narrow brown seam along cord; cell 1st M_2 strongly widened outwardly; male hypopygium with the lateral tergal spines blackened, microscopically setulose before the acute tips.

Male.—Length, about 6-6.5 mm.; wing, 6-6.5 mm.

Female.—Length, about 6.5-7 mm.; wing, 6-6.5 mm.

Rostrum yellow; palpi more darkened, especially the outer segments. Antennæ brownish black; flagellar segments oval, more elongate-oval in male. Head yellow; vertex relatively narrow.

Anterior lateral pretergites yellowish white. Mesonotal praescutum pale reddish or reddish brown, in cases with vague indications of darker stripes; scutal lobes dark brown or brownish black, the median region paler, more silvery; scutellum pale; postnotal mediotergite chiefly blackened, the lateral and cephalic portions narrowly pale. Pleura pale yellow, with a more or less entire, black, dorso-longitudinal stripe, beginning on the propleura, extending to the postnotal mediotergite, best defined as two large areas on the anepisternum and pleurotergite, more nearly interrupted on the dorsal pteropleurite. Halteres pale. Legs with the coxæ and trochanters yellow; femora yellow, the tips more or less infuscated; remainder of legs yellow, the outer tarsal segments passing into brown. Wings whitish, with a relatively narrow brown seam along the cord, narrowed behind, subobsolete on *m-cu*; a scarcely indicated dark seam on outer end of cell 1st M_2 ; vague darkenings across the basal cells; veins brown, darker in the infuscated areas. Venation: Sc_1 ending opposite or just beyond R_2 , Sc_2 pale, beyond midlength of R_3 ; R_2 about one-half R_{2+4} ; cell 1st M_2 strongly widened outwardly; a weak angulation or spur on *m* near its union with M_3 ; cell 2nd *A* relatively wide.

Abdominal tergites dark brown, the basal segments yellow medially; sternites more uniformly pale yellow. Male hypopygium with the tergal spines appearing as blackened, gently curved rods that narrow

gradually to acute points, before their apices fringed with delicate setulæ.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve. Mt. Santa Marta, altitude about 5,000 feet, August 8, 1926 (F. W. Walker). *Allotopotype*, ♀, August 8, 1926, at light, 4 A. M.; *Paratopotypes*, 5 ♂ ♀, August 6-8, 1926.

The most nearly allied species seems to be *N. pervicax* (Alexander) of Peru, which differs in the venation and structure of the male hypopygium, especially the tergal spines.

Gnophomyia Osten Sacken.

Gnophomyia acricula sp. n.

General coloration of mesonotum black; thoracic pleura striped longitudinally with dark and pale; halteres with darkened knobs; legs obscure yellow; wings with a weak brown tinge; *r-m* connecting with *Rs* shortly before the fork; male hypopygium with the outer dististyle a simple, gently curved rod that gradually narrows to a subacute blackened apex.

Male.—Length, about 7 mm.; wing, 6 mm.

Female.—Length, about 7 mm.; wing, 6 mm.

Rostrum and palpi black, paler in the female. Antennæ black throughout; flagellar segments long-oval, with verticils that are subequal to or a little longer than the segments. Head brown; eyes of female apparently larger than in male, approximated or contiguous on the vertex, in the male separated by a strip of moderate width.

Pronotum brownish black. Anterior lateral pretergites restrictedly pale yellow. Mesonotal praescutum black or brownish black, sparsely pruinose; humeral and lateral regions restrictedly brightened; posterior sclerites of mesonotum blackened. Pleura variegated, the dorsal pleurites with a black longitudinal stripe, most intense on the anterior; beneath this stripe on the dorsal sternopleurite a more yellowish area; ventral sternopleurite brown, more or less pruinose. Halteres dark brown or brownish black, the extreme base of stem brightened. Legs with the coxæ and trochanters yellow, the large posterior coxæ, together with the meral region, more conspicuously so; trochanters yellow; remainder of legs obscure yellow, the outer tarsal segments darkened. Wings with a weak brownish suffusion, the stigma scarcely indicated; veins dark brown. Venation: *Sc*₁ ending just before the subevanescent *R*₂, *Sc*₂ opposite *r-m*; *r-m* connecting with *Rs* a short distance before the fork of the latter; *m-cu* opposite *r-m* and a short distance beyond the fork of *M*.

Abdominal tergites blackened; sternites more yellowish; hypopygium dark. In the female, the incisures are slightly darkened. Male hypopygium with the basistyles short and stout. Outer dististyle a simple, gently curved rod, gradually narrowed to the subacute blackened

tip. Inner dististyle with the basal portion expanded, the apical extension obtuse, the whole style with several coarse setæ. What appears to be a tergal structure is a quadrate median plate, the apex decurved into two blunt blackened lobes that are separated by a small notch. Ovipositor with the valves blunt at tips, conspicuously hairy, the sternal valves very short.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker). *Allotopotype*, ♀, August 8, 1926.

Gnophomyia acricula is allied to *G. subhyalina* Alexander, differing especially in the body-coloration, details of venation, and structure of the male hypopygium.

Gnophomyia vilis sp. n.

General coloration pale reddish brown; pleura with a broken blackish longitudinal stripe; femora yellow, the tips weakly infuscated; wings tinged with grayish yellow, the veins yellowish brown; veins R_3 and R_4 long, extending nearly parallel for their entire length; male hypopygium with the outer dististyle a flattened blade, the apex obtuse; ovipositor with the tergal valves short and stout, truncated and setiferous at apex.

Male.—Length, about 6-7 mm.; wing, 5.5-6 mm.

Female.—Length, about 7-7.5 mm.; wing, 6-6.5 mm.

Rostrum pale brown; palpi darker brown. Antennæ brownish yellow, the outer flagellar segments somewhat darker; flagellar segments oval, becoming more slender outwardly, the verticils exceeding the segments. Head obscure yellow, in cases dark grayish brown.

Mesonotum reddish brown, the humeral region and anterior lateral pretergites more yellowish; median area of scutum more yellowish; scutellum more testaceous. Pleura reddish brown, with a conspicuous blackish dorsal stripe, most intense on the anepisternum, paler to subobsolete on the dorsal pteropleurite. Halteres brownish yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow; femora and tibiæ yellow, the tips weakly infuscated; tarsi yellow, the outer segments passing into dark brown. Wings tinged with grayish yellow; veins light yellowish brown. Venation: Sc_1 ending just before R_2 , Sc_2 some distance from its tip; R_2 a little shorter than R_{2+3} ; veins R_3 and R_4 long, running nearly parallel for their entire length; $m-cu$ at from one-third to two-fifths the length of cell 1st M_2 .

Abdominal tergites yellowish brown, darker laterally; sternites more uniformly yellow; hypopygium reddish yellow. Male hypopygium with the outer dististyle a flattened blade, gently arcuated, the apex broadly rounded. Inner dististyle short and stout, blackened, provided with small black setæ, the tip obtuse. Ovipositor with the valves unusually short and stout, the tergal valves truncated at tips, darkened, and bearing a few setæ.

HABITAT: Colombia. *Holotype*, ♂, Orihueca, November 13, 1925 (F. W. Walker). *Allotopotype*, ♀. *Paratopotypes*, 16 ♂ ♀.

Gnophomyia vilis is closest to *G. subhyalina* Alexander, differing in the coloration and venation of the wings and in the structure of the male hypopygium, especially the outer dististyle.

Molophilus Curtis.

***Molophilus flexilistylus* sp. n.**

Belongs to the *plagiatus* group; antennae short; mesonotal praescutum reddish brown, with three more yellowish stripes; knobs of halteres infuscated; male hypopygium with the basal dististyle a long slender rod, expanded at apex, the margin at this point with a series of appressed spines, together with a single larger spine borne on the opposite margin.

Male.—Length, about 3.3-3.5 mm.; wing, 4-4.2 mm.

Female.—Length, about 3.5 mm.; wing, 4 mm.

Rostrum and palpi dark brown. Antennæ short in both sexes, if bent backward not attaining the wing-root, dark brown throughout. Head dark gray.

Mesonotal praescutum with the ground-color reddish brown with three more yellowish stripes; humeral region and anterior lateral pretergites obscure yellow; scutum and scutellum reddish brown, the latter somewhat more testaceous; postnotum brown. Pleura testaceous, the dorsal sclerites more infuscated. Halteres dusky, the knobs infuscated, the color in large part due to abundant dark setæ. Legs with the coxæ and trochanters testaceous; femora and tibiæ brownish yellow; tarsi a little darker. Wings with a brownish tinge, the prearcular and costal regions a little more yellowish; veins pale brown, the macrotrichia dark brown. Venation: Petiole of cell M_3 about one-half longer than *m-cu*; vein 2nd *A* relatively short, ending opposite or just before the caudal end of the oblique *m-cu*.

Abdomen brown, including the hypopygium, the lateral region somewhat darker brown. Male hypopygium with the apical beak of the basistyle slender, gently curved. Basal dististyle a long, slender rod, dilated at apex and here with a lateral series of acute appressed spines, these decreasing in size outwardly; on opposite face, at base of expanded portion of style, with a longer appressed spine. Ovipositor with the valves long and slender, the tergal valves only gently curved.

HABITAT: Colombia. *Holotype*, ♂, La Cumbre, Mt. Santa Marta, altitude 8,000 feet, in deep cloud forest, August 8, 1926 (F. W. Walker). *Allotopotype*, ♀. *Paratopotypes*, 3 ♂ ♀, altitude 7,200-8,000 feet.

The diagnostic features listed above, especially the structure of the male hypopygium, are distinctive of the species. One paratype has the knobs of the halteres much paler, due to depilation.

***Molophilus subtenebricosus* sp. n.**

Belongs to the *plagiatus* group; allied to *M. tenebricosus* Alexander (Colombia: Andes Occidental), differing especially in the structure of the male hypopygium.

Male.—Length, about 4.3 mm.; wing, 5.2 mm.

Antennæ elongate, strongly nodulose. General coloration of mesonotal praescutum blackish gray, with three reddish brown stripes; humeral and anterior lateral pretergites whitish; posterior sclerites of mesonotum, together with the pleura, blackish brown. Halteres pale. Male hypopygium with the apical beak of the basistyle slender, as in *tenebricosus*, but strongly curved. Basal dististyle a long slender rod, the base constricted, beyond this point flattened, with more than the apical third a slender, entirely smooth, black spine; outer aspect of dilated portion of style with abundant appressed setulæ.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 7, 1926 (F. W. Walker).

***Molophilus walkeri* sp. n.**

Belongs to the *plagiatus* group; general coloration brownish gray; halteres yellow; wings obscure whitish, with two vague darker crossbands, one at the cord, the other in the basal cells; male hypopygium with the basal dististyle a powerful blackened rod, the distal two-thirds roughened with spinulae and spinous setae, the tip suddenly narrowed into a blackened spine, at near one-third the length on outer margin with a powerful erect spine.

Male.—Length, about 3.6-3.8 mm.; wing, 4.5-4.7 mm.

Rostrum and palpi black. Antennæ of moderate length, if bent backward extending about to the wing-root, black throughout; flagellar segments oval, gradually decreasing in size outwardly; verticils of basal segments long and conspicuous, becoming shorter and less conspicuous on the outer segments, on the penultimate being scarcely as long as the segment. Head black, sparsely pruinose.

Mesonotum dark brownish gray. Anterior lateral pretergites restrictedly pale yellow. Pleura black, sparsely pruinose. Halteres yellow. Legs with the coxæ black; trochanters brown; remainder of legs black, the femoral bases restrictedly pale. Wings obscure whitish, with two vague darker crossbands, one at the cord, the second more diffuse, crossing the basal cells; veins pale, somewhat darker in the infuscated areas; trichia of veins pale brown, darker and forming

conspicuous patches on those veins traversing the infuscated areas, especially along the cord. Venation: *m-cu* oblique, subequal in length to the petiole of cell *M*₃; vein *2nd A* ending shortly beyond the caudal end of *m-cu*.

Abdomen brownish black, including the hypopygium. Male hypopygium with the apical beak of the basistyle decurved to an acute point. Outer dististyle relatively slender, bifid at apex. Basal dististyle a powerful blackened rod, the apex narrowed into a blackened spine, the distal two-thirds of the style with abundant appressed spinulæ on all faces, those of the ventral or inner face more slender and spinous; on outer margin of style at near one-third the length with a powerful erect spine.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude 5,000 feet, August 8, 1926, at light, 4 A. M. (F. W. Walker).

Molophilus walkeri is respectfully dedicated to the collector of this abundant series of Tipulidæ from Santa Marta, Mr. Fred W. Walker. The structure of the male hypopygium is distinctive.

Molophilus marthæ sp. n

Belongs to the *plagiatus* group; general coloration of mesonotal praescutum reddish brown, the postnotum and pleura blackened; antennæ relatively long, extending to beyond the wing-root; knobs of halteres infuscated; legs dark brown; wings tinged with brown, the long abundant macrotrichia dark brown; male hypopygium with the basal dististyle a powerful rod, the distal half fringed with setae and appressed spines; basal half of style on outer face with two powerful erect spines.

Male.—Length, about 3.5 mm.; wing, 4.4 mm.

Rostrum and palpi black. Antennæ black, relatively long, if bent backward extending to beyond the wing-root; flagellar segments oval, with long, unilaterally arranged verticils and additional long delicate setulæ. Head dark brown.

Mesonotal praescutum reddish brown, the anterior lateral pretergites whitish; scutal lobes and scutellum darker, the postnotum blackened. Pleura blackened. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters yellow to testaceous yellow; remainder of legs dark brown. Wings with a faint brown tinge, more evident as a seam along vein *Cu*; veins pale brown, the long abundant macrotrichia dark brown; costal fringe long and dense. Venation: *m-cu* about two-thirds the length of the petiole of cell *M*₃; vein *2nd A* long, gently sinuous, ending beyond midlength of the petiole of cell *M*₃.

Abdomen brownish black, the hypopygium more yellowish. Male hypopygium with the apical beak of basistyle slender and straight; margin of basistyle cephalad of beak extensively blackened and

microscopically roughened. Outer dististyle relatively stout, bifid, the inner arm more elongate. Basal dististyle a powerful rod, the distal half or slightly less narrowed to a gently curved spine, the concave face provided with a dense fringe of setæ in addition to a series of appressed spines; basal half of style more enlarged, with two powerful erect spines. Phallosomic structure small, oval, glabrous.

HABITAT: Colombia. *Holotype*, ♂, Vista Nieve, Mt. Santa Marta, altitude about 5,000 feet, August 6, 1926 (F. W. Walker).

Molophilus marthæ is very distinct from all described species of the genus in the structure of the male hypopygium.

***Molophilus bidigitatus* sp. n.**

Belongs to the *plagiatus* group; general coloration reddish brown, the head, pronotum and humeral regions of praescutum light yellow; thoracic pleura dark brown; halteres yellow; wings grayish yellow, the costal region clearer yellow; male hypopygium with the basal dististyle bifurcate at apex; phallosomic structure a pale setiferous cushion, its caudal end bifid.

Male.—Length, about 2.5 mm.; wing, 3.3 mm.

Rostrum and palpi brown. Antennæ with the scape yellow, the flagellum broken. Head pale yellow, more infuscated behind.

Pronotum and anterior lateral pretergites light sulphur-yellow. Mesonotum reddish brown, the humeral region of praescutum light sulphur-yellow; posterior sclerites of mesonotum somewhat darker brown. Pleura dark brown, the dorso-pleural region chiefly darkened, the posterior portion yellow. Halteres yellow, with golden setæ. Legs with the fore coxæ infuscated, the remaining coxæ and all trochanters yellow; remainder of legs broken. Wings grayish yellow, the base and costal region clearer yellow; veins pale, the macrotrichia brown. Venation: *m-cu* about two-thirds the petiole of cell M_3 ; vein 2nd *A* relatively elongate, extending to about opposite one-third the length of the petiole of cell M_3 .

Abdomen yellowish brown, darker laterally; hypopygium yellow. Male hypopygium with the apical beak of basistyle slender, gently curved. Outer dististyle bifid, the inner arm more slender. Basal dististyle having much the same shape as the apex of the outer dististyle, being conspicuously bifurcate, both arms appearing as slender blackened spines, the outer arm more curved and a little stouter than the inner spine; stem short. Phallosomic structure a pale cushion that is covered with long conspicuous setæ, the apex deeply notched medially. Aedeagus relatively short, subequal in length to the outer dististyle.

HABITAT: Brazil. *Holotype*, ♂, Jaragua, Santa Catharina, August 21, 1929 (F. Schade).

Molophilus bidigitatus is very distinct from all described Neotropical species in the structure of the basal dististyle of the male hypopygium.

A REVISION OF THE MALES OF THE NEARCTIC SPECIES IN THE GENUS *FABRICIELLA* (TACHINIDÆ)*

JOHN ALLEN ROWE.

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INTRODUCTION.

In 1924 J. D. Tothill revised the nearctic species in the genus *Fabriciella*, a name proposed by Bezzi in 1906 to replace *Fabricia* Rob. D. which is preoccupied. All species having the genital forceps agreeing with that of the genotype, *F. ferox* Panz., were included. Twenty-five species were included in the revision, eighteen of which were new. The species were separated on the basis of the genitalia of the males, but the descriptions and key are so inadequate that recognition of the species from this treatise is very difficult.

In this paper an attempt has been made to furnish for the males of the known nearctic species, including three here described as new, a treatment by which they may be definitely recognized. All species have been compared with types and paratypes now in the national collections. The descriptions emphasize genital differences, and figures of the male genitalia of all species are included.

*Contribution from the Zoological Laboratories of the University of Utah, Salt Lake City, Utah. No. 55.

At this time opportunity presents itself to acknowledge my indebtedness to those who have aided in the preparation of this paper. To Dr. J. M. Aldrich, U. S. National Museum, and C. H. Curran, American Museum Nat. History, I wish to express sincere appreciation for the loan of material, checking of species, and many valuable notes pertaining to this problem. To Dr. J. McDunnough of the Canadian National Museum, I wish to express sincere thanks for the new species described, and for figures of the genitalia of *F. longiunguis* Tot., *F. nivalis* Tot., and *F. canadensis* Tot. The work was completed under the supervision of Dr. Ralph V. Chamberlin, head of the Department of Zoology, at the University of Utah, whose kindly suggestions and valuable assistance were indispensable. Finally to my associates and fellow workers whose interests and encouragements have been most generous, I wish to express sincere thanks.

GENERIC CHARACTERISTICS.

The genus *Fabriciella* comprises those flies of the family Tachinidae which have the following characteristics. Length ranging from 8–16 mm. Body robust and in most cases heavily bristled. Wings well developed and often tinged with orange near the base. Legs in all cases robust, with well developed pulvilli and claws.

Head as wide at the vibrissae as at the base of the antennae. Vibrissae situated far above the oral margin. Labial palpi well developed, yellow, bristled, and in most cases thickened on the distal end. Eyes not hairy. Genae pollinose, in many cases bearing black hairs. Frontal row well developed, and extending well below the base of the antennae. Ocellars present and directed forward. Post-ocular region densely covered with long white, golden, or yellow pile. Oculars directed backward. Facial depression usually shallow, pollinose and without median carina. Second segment of the antennae longer than the third. Arista usually thickened on the basal three-fourths.

Thorax dark and polished. Sternopleurals three. Dorsocentrals four. Scutellum with three to five marginals. (The number of bristles of the thorax is variable.) Post-scutellum prominent, pollinose. Squamae large, yellowish or white. Wings of the general Tachinid type with a few small bristles at the base of the third vein. Legs robust, heavily bristled. Claws and pulvillae well developed.

Abdomen black or orange with black mid-dorsal stripe. Second and third tergites with or without discal bristles and with well developed marginal bristles. Apex of abdomen heavily bristled.

Male genitalia usually very prominent. Forceps either greatly arched or flat. Processes of the accessory plates usually curved tusk-like, giving the appearance of a ring. Fifth sternite cleft, the cleft taking varied appearances, usually V-shaped or U-shaped.

CHARACTERS OF THE GENITALIA.¹

Workers in all fields are beginning to pay more and more attention to the specific differences in the genitalia as a basis for the separation of species. This is due to the fact that in many cases the general morphology, size, and color have been found to be quite variable while the differences between species presented in the genital organs are constant.

The genitalia of the flies belonging to the genus *Fabriciella* comprise the abdominal segments beyond the fourth tergite and the fifth sternite. They are arranged successively, some being modified into organs specialized for copulation. The first genital segment (G. Plate I, Figure 1) is situated just beyond the fourth tergite. It serves as a base for the attachment of the following parts. Adjacent caudally to the first genital segment is the second genital segment (G2. Plate I, Figure 1) which bears the forceps, accessory plates and anal area. It is the largest of the genital segments and usually the most conspicuous. It is often specialized on the ventral margin, as in the case of *F. algens* Wd., and *F. latianulum* Tot., into laterally projecting flaps and in one case, *F. spinosa* Tot., bears a group of short spines. These specializations serve excellently in separating the species. Caudad of and attached to the second genital segment are the accessory plates (AP. Plate I, Figure 1). These plates are also important as specific characters, some being prominent and some being completely hidden in lateral view by the forceps and second genital segment. They are modified on the lower end into characteristic tusk-like processes (PAP. Plate I, Figure 1) which extend ventrally and curve toward each other in the form of a ring. They serve as probers and claspers in the copulatory process. The forceps (F. Plate I, Figure 1) is the most posterior segment of the genitalia. Its size and shape is characteristic of the species; for this reason it is the most important morphological structure used in the classification of this group. In regard to its various sizes and shapes the reader is referred to the figures on the accompanying plates. Dorsally, between the forceps and the second genital segment the anal area (AA. Plate I, Figure 1)

¹As indicated by the title and in the introduction this paper deals with males and male genitalia only. Accordingly the key given in this paper cannot be used for females.

is located. It is easily recognized because it is membranous in character. It has various shapes, the most common being oblong, oval, and cordate. In many cases the anterior end is acutely angled.

Seated in a depressed ventral area between the latero-ventral margins of the second genital segment are the two pairs of claspers, the penis, and the genital sternum. In this area, projecting inward between the sides of the second genital segment is a chitinized plate which is held in place by membrane. This is the genital sternum (GS. Plate I, Figure 1) and serves as a base of attachment for the claspers and penis. Situated posteriorly on the sternum are the posterior claspers (PC. Plate I, Figure 1). They are small chitinized rods, blunt and somewhat enlarged on the end, either straight or gently curved, seated side by side and projecting over the penis. Anterior to the posterior claspers and originating under them are the anterior claspers (AC. Plate I, Figure 1). They are chitinized, usually larger than the posterior claspers, produced ventrally a short distance and then bent anteriorly thus appearing in the shape of a right angle. Both pair of claspers are used in clasping the female in copulation. The penis (P. Plate I, Figure 1) is usually well concealed by the anterior claspers and only a part of it can be seen without making a dissection. It is made up of a posterior chitinized part which at the distal end forms a ring, and a membranous distal part which projects from the ring in the form of a hollow tube.

Another structure may be mentioned here because of its specialization and close proximity to the genitalia. The fifth sternite (5St, Plate I, Figure 1) is quite characteristic because of its variously shaped cleft (C5St, Plate I, Figure 1) and processes (P5St, Plate I, Figure 1). This structure is used often as an important character in classification.

The nomenclature used in the description of the genitalia as well as in the general description of species is essentially that used by Dr. J. M. Aldrich in his well known treatise, "Sarcophaga and Allies," Vol. I, Thomas Say Foundation.

KEY TO SPECIES.

1. Abdomen with conspicuous orange colored markings.
2. Dorsal surface of forceps flattened, or at least not strongly arched.
 3. Second genital segment truncate ventrally, beak or forcep abruptly acuminate. Plate I, Figure 1. *acuminata* Tot.
 - *3. Second genital segment not truncate. Parafrontals shining.
 4. Ventral surfaces of the second genital segment with no large bristles.
 5. Second genital segment inflated dorsally, forceps caudally appearing heart-shaped. Plate I, Figure 2. *cordiforceps* n. sp.
 - *5. Second genital segment not so, beak with medium long, sharp tip. Plate I, Figure 3. *florum* Wlk.
 - *4. Ventral surfaces of the second genital segment with large bristles.
 6. Beak of forceps narrow, bristles only on extreme ventral surface. Plate I, Figure 4. *spinosa* Tot.
 - *6. Beak of forceps very wide with the tip turned under. Plate I, Figure 5. *lutzi* Curr.
 - *2. Dorsal surface of forceps distinctly arched.
 7. Beak of forceps with very small tip.
 8. Beak of forceps as broad as long, last segment of tarsus silvery pollinose. Plate I, Figure 6. *argentina* n. sp.
 - *8. Beak of forceps not as broad as long.
 9. Lateral ridges of beak ovately converging to a small tip. Plate I, Figure 7. *longiunguis* Tot.
 - *9. Lateral ridges of beak parallel.
 10. Cleft of fifth sternite V-shaped. A very pilose species. Plate II, Figure 8. *pilosa* Tot.
 - *10. Cleft of fifth sternite narrowing above, parallel sides of beak long. Plate II, Figure 9. *montana* Tns.
 - *7. Beak of forceps blunt or nearly so.
 11. Beak of forceps very narrow, angularly blunt. Plate II, Figure 10. *latigena* Tot.
 - *11. Beak of forceps wider and roundly blunt. Plate II, Figure 11. *latifacies* Tot.
 - **7. Beak of forceps with well extended tip.
 12. Lateral ridges of beak parallel, forceps densely bristled, abdomen without discals. Plate II, Figure 12. *canadensis* Tot.
 - *12. Lateral ridges of beak not parallel.
 13. Beak flat dorsally, hard part of probosis very short. Plate II, Figure 13. *brevirostris* Tot.
 - *13. Beak concave dorsally, forceps very heavily bristled. Plate III, Figure 14. *nivalis* Tot.
- *1. Abdomen black or nearly so.
 14. Second genital segment produced ventrally into a process bearing stout pines.
 15. Processes of the accessory plates blunt and heavy, forceps large, beak long. Plate III, Figure 15. *latianulum* Tot.
 - *15. Processes of the accessory plates sharply pointed, beak short.
 16. Spines of ventral process long and comb-like, cleft of the fifth sternite V-shaped. Plate III, Figure 16. *algens* Wd.
 - *16. Spines of the ventral process very short, beak very short, cleft U-shaped. Plate III, Figure 17. *spheiventer* Tot.
 - *14. Second genital segment with no such processes.
 17. Accessory plates reduced or nearly hidden from the lateral view.
 18. Forceps small, beak reduced, parafrontals shining black. Plate III, Figure 18. *latifrons* Tot.
 - *18. Forceps well developed, beak prominent.
 19. Forceps laterally appearing like the head of a chicken with long beak. Plate III, Figure 19. *rostrata* Tot.
 - *19. Forceps much larger, constricted in the middle; third segment of antennae truncate. Plate IV, Figure 20. *nitida* v. d. W.

- *17. Accessory plates distinctly visible from the lateral view.
 - 20. Beak of forceps as broad as long, flat. Cleft acute on the bottom. Plate IV, Figure 21.....**latiforceps** Tot.
- *20. Beak of forceps not as broad as long.
 - 21. Lateral ridges of the beak not parallel, processes of the accessory plates flat on the inner surface. Plate IV, Figure 22.....**emarginata** Tot.
- *21. Lateral ridges of the beak parallel, processes of the accessory plates round.
 - 22. Beak gradually tapering to a sharp point, cleft U-shaped. Plate IV, Figure 23.....**piceifrons** Tns.
- *22. Beak tapering abruptly to a blunt tip, forceps inflated on the caudal margin. Plate IV, Figure 24...**hispida** Tot.
- **22. Beak with long, sharp tip, forceps and accessory plates very large. Plate IV, Figure 25.....**ampliforceps** n. sp.

DESCRIPTION OF SPECIES.

Fabriciella acuminata Tothill.

Canadian Entomologist, Vol. 24, 1925, p. 260.

Length, 8.5 mm. Parafrontals about as wide as half the length of the second segment of antennæ, black in ground color, white pollinose, bearing a few black hairs. Frontal vitta about as wide as parafrontals, reddish, widening near the antennæ. Frontals numbering eleven to fourteen. Ocellars pointing obliquely forward; verticles large, two pair at the apex of compound eye and two smaller pair posterior of the ocelli. Post-ocular row distinct. Post-ocular region covered with long yellow pile. Genæ narrower than the length of the third antennal segment, yellow pollinose, bearing scattered black hairs. Buccal region yellow pollinose, bearing mostly yellow hairs. Vibrissæ large. Vibrissal ridges distinct but not prominent, bearing three or four small bristles above the vibrissæ. Buccal row irregular, medium large. Antennæ reaching the lowest fifth of the facial depression, first and second segments yellowish brown, bearing a few bristles and black hairs; third segment nearly ovoid, dark brown to black. Arista black, tapering gradually, second segment at least four times as long as wide. Mouth parts normal. Labial palpi club shaped, yellow, and bearing short black hairs. Proboscis black, chitinized portion once and a half longer than antenna.

Pleura black, highly polished. Sternopleural bristles three. Notum black, highly polished. Dorsocentrals four. Scutellum at the base black, at the apex light brown. Marginal bristles of the scutellum eight in number, three pairs being large, the other pair reduced. Post-scutellum black. Length of left wing, 6.7 mm. Legs quite robust. Claws long, brown and curved near the tip.

Abdomen covered with small black bristles, yellow except for a black dorsal stripe which ends before reaching the posterior margin of the fourth tergite. Second segment bearing one pair of median marginal and two pairs of lateral marginal bristles. Margins of the third and fourth tergites bearing large bristles. Sternites all thickly set with

medium stout bristles. Genital segments prominent, dark brown or black.

Genitalia: (Plate I, Figure 1). First genital segment (G1) dark brown, polished, bearing a few medium large bristles on the dorsal surface; as wide as the second genital segment (G2) but narrowing on the ventral margins. Second genital segment distinctly brown, longer ventrally than dorsally, margin nearest the beak of the forceps (F) acutely angled, bearing black hairs on all surfaces. Accessory plates (AP) very prominent, fully a third as wide as the second genital segment, chocolate brown and highly polished. Processes of the accessory plates (PAP) nearly as long as the accessory plates, and very abruptly pointed. Anal area (AA) large. Forceps (F) flat, horizontal length not more than that of the accessory plates, beak of forcep very rudimentary, forcep bearing thick black hair on all surfaces except a small area near the beak. Posterior claspers (PC) very short, no longer than one-third the length of the anterior claspers (AC). Anterior claspers longer than the processes of the accessory plates, curved ventrally and anteriorly respectively. Penis (P) long, extending well past the processes of the fifth sternite. Fifth sternite (5St) as wide as genital segments, bearing medium high rounded, blunt processes. Cleft of the fifth sternite narrow, but as deep as half the length of the sternite.

Redescribed from a single specimen in the collection of the University of Utah, and determined by J. M. Aldrich, 1930.

Distributional records: Maple Canyon, Sanpete Co., Utah, 1923 (Shaler Aldous); Colorado.

Holotype: Male (B. and B. No. 52); Colorado; in the U. S. National Museum.

Paratype: Male, Colorado, (C. V. Riley); No. 810 in the Canadian National Collection, Ottawa.

***Fabriciella cordiforceps*, n. sp.**

Length, 14.9 mm. Parafrontals dark in ground color, yellow pollinose, at the ocelli slightly narrower than the narrowest width of the frontal vitta, bearing numerous yellow hairs. Frontal vitta reddish-purple, narrowest width two-thirds the length of the second antennal segment. Frontals prominent. Vertex black in ground color, silvery pollinose. Post-ocular row ending before the ventral margin of the eye. Genæ at its narrowest width as wide as the length of the second antennal segment, yellow pollinose bearing short, scattered yellow hairs. Buccæ once and a half as wide as the genæ, yellow pollinose, and bearing only yellow hairs. Vibrissal ridges not prominent. Buccal row intact.

Second segment of the antennæ light brown, bearing numerous minute bristles and two medium large bristles on the dorsal margin; third segment black, except on the proximal third which is light brown. Arista two-thirds as long as the combined length of the second and third antennal segments, gradually tapering, the second segment at

least four times as long as wide. Mouthparts normal. Labial palpi yellow, and as long as the chitinized part of the proboscis. Proboscis from the articulation once and a third the length of the antennæ.

Pleura black, except for a spot of light brown above the sternopleura, polished. Sternopleurals three. Notum black in ground color, having intermittent spots of white pollinose, lateral border light brown. Dorsocentrals medium large, four. Scutellum brown, bearing five pairs of marginals and two pairs of sub-marginals. Length of right wing, 11.3 mm. Legs dark, the tibia of the second and third being distinctly lighter than the other segments. Claws of the second as long as the last two tarsal segments.

Abdomen orange, except for a shadow of black dorsal stripe. Anterior margin of each tergite silvery pollinose. Second tergite bearing a single pair of lateral marginals and a pair of median marginals. Genital segments small, orange.

Genitalia: (Plate I, Figure 2.) First genital segment (G1) small. Second genital segment (G2) twice as wide as long, irregularly brown and orange in color, exceedingly bristled on the dorsal surface. Accessory plate (AP) prominent, brown and highly polished. Processes of the accessory plates (PAP) curved ring like, their tips nearly touching, flat on the inner surface, and bearing a few light colored hairs. Forceps (F) small, brown except at the beak (B) which is black, slightly arched; when viewed from the caudal aspect, it appears heart shaped. Anal area (AA) oval. Posterior claspers (PC) shorter than the anterior claspers (AC) black and slightly curved. Penis (P) small, chitinized portion quite hidden by the anterior claspers. Fifth sternite (5St) orange, bearing only medium large bristles on the posterior half. Cleft of the fifth sternite (C5St) as deep as half the length of the segment, narrow at the bottom but widening rapidly at the top.

Holotype: Male, Pine Val. Mts., Utah, 7,000 feet, Brooklyn Museum Collection, 1929; in the Canadian National Collection, Ottawa.

Paratypes: Two males, Oak Creek Canyon, Arizona, 6,000 feet, August, F. H. Snow; in the Canadian National Collection, Ottawa. One male, same data as paratype above; in the collection of the University of Utah, Salt Lake City.

One female, same data; in the collection of the University of Utah.

Allotype: One female, same data as paratypes; in the Canadian National Collection, Ottawa.

Fabriciella florum Walker.

Echinomyia florum Wlk. 1849, Walker's List No. IV, 722.

Echinomyia dakotensis Tns. 1892, Trans. Am. Ent. Soc. XIX, 94.

Fabriciella orientalis Wlk. Tothill, Can. Entomologist, Vol 56, 1924, p. 259.

Length, 11.2 mm. Parafrontals wider than half the length of the second antennal segment, mostly black, polished, bearing scattered

black hairs. Frontal vitta at the narrowest width less than half the length of the second antennal segment, reddish brown. Post-ocular row distinct, running to the margin of the buccal region. Post-ocular pile white. Genæ as wide as two-thirds the length of the second antennal segment, white pollinose, bearing scattered black hairs. Buccal region about as wide as the combined length of the second and third antennal segments, golden pollinose bearing scattered black and yellow hairs. Buccal row intact. Vibrissal ridge prominent. First and second segments of the antennæ light brown, bearing numerous short black hairs; second segment with a medium large bristle on the dorsal surface; third segment laterally appearing subquadrate, dark brown to black. Arista brown, second segment at least four times as long as wide. Mouthparts normal. Chitinized portion of proboscis, heavy, slightly shorter than the combined length of the second and third antennal segments.

Pleura dark brown to black, highly polished. Sternopleurals three. Notum black, polished. Scutellum black except at the apex which is brown, bearing three pair of marginals, and two pairs of submarginals. Wings hyaline. Length of right wing, 8.7 mm. Legs quite robust, black.

Abdomen yellow except for a mid-dorsal black stripe. Second tergite bearing a pairs of median marginal bristles, and a single pair of lateral marginal bristles. Sternites somewhat darker in color than the tergites and heavily bristled. Genital segments subprominent, dark brown.

Genitalia: (Plate I, Figure 3.) First genital segment (G1) polished, black, slightly wider than the second genital segment (G2); dorsal width much greater than ventral width, dorsal surface bristled. Second genital segment polished, brown, bearing medium large bristles on only the dorsal surface; ventral width greater than dorsal width. Accessory plates (AP) strikingly large, brown, bearing no hair. Forceps (F) black, greatly flattened, projecting dorsally over the anal area (AA). Beak of forceps flat, sharply pointed, falcate, heavily chitinized. Processes of the accessory plates (PAP) slightly heavier than the posterior claspers, curved tusk-like, black, bearing a few small yellow hairs. Anal area (AA) large, somewhat spherical in shape. Posterior claspers (PC) heavier and shorter than the anterior claspers (AC), brown, strongly curved, and of an equal width throughout. Anterior claspers (AC) brown, longer and narrower than the posterior claspers. Penis (P) quite small, chitinized portion not projecting in front of anterior claspers, membranous portion projecting in front of the anterior claspers a distance equal to half the length of a posterior clasper. Fifth sternite (5St) unusually large, as long as the combined length of the second genital segment and forcep. Cleft of the fifth sternite (C5St) as deep as half the length of sternite.

Redescribed from specimens determined and sent to me by Dr. J. M. Aldrich, March 28, 1930.

Distributional records: One female which shows the record of Forest Hills, Mass., 10-11-16, collector unknown. Martin

Falls and Nova Scotia, Canada; White Mountains, N. H. (Slosson); Axton, N. Y., (M. and H.); Province of Quebec, Canada, (Fyles).

The revision of 1934 recognizes *F. orientalis* Tns. and *F. dakotensis* Tns. as distinct species, but fails to recognize *F. florum* Wlk. on the basis of genitalia. These species have been checked, and although there are slight differences in colorations the genitalia are identical. I think the three are synonymous, and that the name should be *F. florum* Wlk. It is treated as such in this paper.

Fabriciella spinosa Tothill.

Canadian Entomologist, Vol. 56, 1924, p. 263.

Length, 12.4 mm. Parafrontals at their narrowest width, equal to about one-half the length of the second segment of the antennæ, dark in ground color, yellow pollinose, bearing a few weak bristles. Frontal vitta reddish, almost as wide as the length of second segment of antennæ. Frontals prominent. Ocellars medium large, pointing obliquely forward. Post-oculars prominent. Post-ocular region covered with long yellow pile. Genæ nearly as wide as second antennal segment, bearing scattered black pile. Buccal region bearing long black and yellow pile. Vibrissal ridges sub-prominent bearing few bristles above vibrissæ. Buccal row intact. Vibrissæ large. First and second segments of antennæ yellowish brown, third segment black except at its attachment where it is yellowish. Second segment bearing short stout spine near its distal end. Arista black and tapering gradually, second segment three times as long as wide. Mouth parts normal. Labial palps yellow and bearing short stout bristles on the distal end. Proboscis stout, once and a third as long as antennæ.

Pleura and venter polished black. Notum black except at the lateral margins which are brown, sub-polished at intervals, making it appear blue striped. Scutellum brownish, bearing three pairs of strong marginals and one pair of weak marginals. Post-scutellum prominent, white pollinose. Sternopleurals three. Dorsocentrals four. Legs rather robust, black except the tibia which is light brown. Claws large, yellow and tipped black. Wings hyaline. Length of right wing, 10.5 mm.

Abdomen yellowish brown, covered with stout short bristles. Second segment bearing a pair of median marginals, and a pair of lateral marginals. Genital segments prominent.

Genitalia: (Plate I, Figure 4.) Genital segments dark brown to black, first genital segment (G1) wider than the second genital segment (G2) and bearing medium large bristles on the dorsal surface. Second genital segment laterally appearing oval, bearing strong bristles on dorsal surface and a cluster of short stout spines near the margin just in front of the accessory plates. Accessory plates (AP) very distinct,

terminating in a tusk-like, abruptly pointed process (PAP). Forceps (F) rudimentary, knob-like, hardly projecting, covered with black hairs. Posterior claspers (PC) projecting ventrally, blunt and thickened on the end, about as long as the anterior claspers (AC) but not so stout. Anterior claspers pointing anteriorly, and slightly hooked on the end. Penis (P) longer than either claspers, chitinated portion rather thin. Genital sternum (GS) very prominent, and heavily chitinated. Fifth sternite (5St) large, covered with stout bristles. Processes of the fifth sternite (P5St) quite long, projecting posteriorly and blunt.

Redescribed from a series of six males in the collection of the University of Utah. Determined by Dr. J. M. Aldrich, 1930.

Distributional records: Maple Canyon, Sanpete Co., Utah, 1923 (Shaler Aldous); Parowan Canyon, Utah, 1923 (H. R. Hagen); Box Canyon, Sanpete Co., Utah, 1924 (H. R. Hagen), Brice Canyon, Utah (V. M. Tanner). Three males, same data as allotype and one male from Los Angeles Co., California, in the U. S. National Museum.

Holotype: Male, Peachland, B. C., 1917 (J. B. Wallis); No. 800 Canadian National Collection, Ottawa.

Allotype: Female, Mountains near Claremont, California (Baker); in Canadian National Collection, Ottawa.

***Fabriciella lutzi* Curran.**

Canadian Entomologist, Vol 57, 1925, p. 256.

"Length, 13 mm. Male. Face, and cheeks yellowish in ground color. Head silvery white pruinose; frontal vitta rusty brown. Width of front one and three-sevenths greater than length of second antennal joint; parafacial five-sevenths as wide as length of second antennal joint; hair of occiput yellow, of cheeks yellow, coarse, with some black hairs intermixed, the parafacials with coarse yellow hair on lower half, black above. Front with fine yellow hairs along the orbits. Cheeks one-half as wide as eye height. Palpi yellowish. Antennae reddish, third joint blackish.

Mesonotum rather thinly cinereous pollinose, the vittae moderately distinct; humeri and lateral margins rusty-reddish. Scutellum rusty-reddish.

Legs black. Wings cinereous, yellowish antero-basally. Squamae white; halteres orange.

Abdomen rusty yellow, darker apically; with a narrow median black vitta which is broadly interrupted on the third and fourth segments or narrowly so on the third, the spot on the third segment triangular, widest at apex, the fourth segment black on apical half. Bases of second to fourth segments broadly white pollinose, the second less widely so. Genitalia black. Intermediate abdominal segments without discals." (Curran's original description.)

Genitalia: (Plate I, Figure 5.) Genital segments dark brown to black. First genital segment (G1) polished, and bearing few or no large bristles. Second genital segment (G2) longer ventrally than dorsally, bearing numerous stout spines on the ventral half. Accessory plates (AP) well developed, dark-brown and polished. Processes of the accessory plates (PAP) long and narrow. Forceps (F) slightly arched, hairy. Beak of the forceps (B) very broad caudally, its lateral ridges parallel and its tip folded under. Anal area (AA) long and narrow. Posterior claspers (PC) greatly curved and slightly more prominent than the anterior claspers (AC). Fifth sternite darker caudally, its cleft (C) shallow and acute on the bottom.

Genitalia redescribed from a male, Richfield, Utah, August, 1930 (J. A. Rowe), in the collection of the University of Utah, Salt Lake City.

Holotype: Male, Rifle, Colorado, July 19–21, 1919, (F. E. Lutz); in the American Museum of Natural History.

Paratypes: Male, same data, No. 1443, in the Canadian National Collection, Ottawa. Male, near Lander, Wyoming, August, (Roy Moody); in the Kansas University Collection.

***Fabriciella argentea* n. sp.**

Length, 11.1 mm. Narrowest width of the front less than the eye width. Parafrontals at their narrowest width equal to half the width of the frontal vitta; polished black above and yellow pollinose below. Post-ocular region yellow pollinose. Post-ocular pile thin and white. Narrowest width of the genæ equal to two-thirds the length of the second antennal segment, yellow pollinose and bearing scattered black hairs. Second segment of the antennæ dark brown, third segment oblong-oval, and nearly as long as the second. Arista thickened on at least the proximal three-fourths, second segment at least twice as long as wide.

Pleura polished black. Sternopleurals three and weak. Notum polished black. Dorsocentrals weak. Scutellum lighter than the notum, with five pairs of marginals and few prominent submarginals. Last segment of the tarsi silvery pollinose.

Abdomen with lateral orange spots. Sternites and ventral part of tergites and mid-dorsal stripe black. Second tergite with two pairs of median marginals, and four pairs of lateral marginals.

Genitalia: (Plate I, Figure 6.) Genital segments black. First genital segment (G1) polished black, and bearing a prominent dent at the middle of the dorsal surface. Second genital segment longer ventrally than dorsally, with few or no large bristles. Accessory plates (AP) prominent for their entire length, polished brown. Anal area (AA) oblong-oval. Forceps (F) distinctly arched. Beak (B) wide, concave, and with a sharp abruptly acuminate tip. Cleft of the fifth sternite (C) as deep as half the length of the sternite, acute on the bottom.

Holotype: Male, Banff, Alta., 9, viii, 1922, C. B. D. Garrett. In the Canadian National Museum, Ottawa.

***Fabriciella longiunguis* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 265.

"Width of front equal to three-fourths of the length of the second antennal segment. Second antennal segment a little longer than the third. Parafrontals opaque, narrowest width rather greater than that of the front. Genæ pollinose, with sparse black hairs above. Proboscis and palpi normal. Front tarsi slightly dilated, the claws as long as the last three tarsal segments. Abdomen, including the sternites, orange except for a dorsal black vitta that widens posteriorly to include most of the fourth tergite. Forceps strongly arched longitudinally and terminating in a broad somewhat concave shining plate". (Tothill's original description).

Genitalia: (Plate I, Figure 7.) Dr. J. McDunnough has kindly furnished the following notes on the genitalia of the Holotype. "Forceps bear heavy spines which are stoutest along lateral face and become longer posteriorly. There are fine hairs interspersed especially along median line."

Holotype: Male, Vernon, B. C., no date, (M. H. Ruhmann); in the Canadian Nat. Collection, Ottawa.

***Fabriciella pilosa* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 263.

Length, 10.2 to 13.6 mm. Parafrontals at the ocelli one-half as wide as the frontal vitta, from the side appearing black, but from the front yellow pollinose except near the ocelli which is shining black. Front margin of the compound eye constricted making the front appear projecting. Frontal vitta reddish-purple, widening toward the antennæ. Frontals prominent. Vertex black. Verticles long. Post-ocular row ending before reaching the ventral margin of compound eye. Post-ocular region black except for intermittent light pollinose spots, pile dull yellow. Genæ at its narrowest part as wide as two-thirds the length of the second antennal segment, light pollinose and bearing many black hairs. Bucca brown in ground color, light pollinose and bearing many black hairs. Vibrissal ridge sub-prominent, bearing five or six bristles above vibrissæ. Vibrissæ small. Second segment of the antenna light brown, one-fifth longer than the third; third segment black except near the joint which is brown. Arista much shorter than the combined length of the second and third antennal segments, second segment slightly more than twice as long as wide; third segment heavy on proximal half and fine on distal half. Mouthparts normal. Labial palps yellow. Proboscis, from the articulation, almost twice as long as antennæ.

Pleura dark brown to black, polished, black pilose. Sterno-pleurals three and large. Notum black, pilose and polished. Dorsocentrals large. Post-scutellum lighter than notum, bearing seven pairs of large marginals. Length of right wing, 10.9 and 8.5 mm. Legs dark brown. Claws of the third only slightly longer than the last tarsal segment.

Abdomen polished, black except for an orange spot on the sides of the tergites, black pilose. Second tergite bearing three pairs of median marginals and three pairs of lateral marginals. Second and third tergites bearing four or five large distal bristles. Sternites thickly black pilose.

Genitalia: (Plate II, Figure 8.) First genital segment (G1) dark brown, polished, bearing few large bristles. Second genital segment (G2) brown, polished, black pilose but with few or no large bristles. Accessory plates (AP) very distinct from a lateral view, brown, not hairy. Processes of the accessory plates (PAP) black, round, long acuminate and sharp. Forceps (F) black, very hairy; from the lateral view appearing arched to the extent of over half the length of the second genital segment. Beak (B) almost round apically, flat, and concave dorsally. Anal area (AA) large extending nearly half the length of the second genital segment. Posterior claspers (PC) brown, equally as heavy as the anterior claspers (AC). Penis (P) prominent, extending in front of the anterior clasper to the extent of over half of the anterior claspers, membranous part very pronounced. Fifth sternite (5St) very pronounced, appearing inflated. Cleft (C) deeper than half the length of the sternite, the bottom being very narrow. Processes of the fifth sternite (P5St) prominent and wide apart.

Redescribed from two paratypes: Male, Bear Lake, B. C., R. P. Currie, collector, No. 40145 in the U. S. Nat. Museum; loaned by J. M. Aldrich. Male, Hedley, B. C., July 25, 1923, C. B. Garrett, collector, No. 801 in the American Museum of Nat. History; loaned by C. H. Curran.

Paratypes: Five males, London Hill Mine, B. C., (R. P. Currie); three males, Hedley, B. C., July 25, 29, 1923, (Garrett); three males, Banff, Alta, August 9, (Garrett); one male, Truchas Peak, N. M. (W. P. C.); one male, White Mts., Scudder. In the U. S. National Museum.

***Fabriciella montana* (Townsend).**

Echinomyia florum Coquillett (nec Walker). Rev. Tachin, 1897, p. 144.

Fabricioides montana Townsend, Insec. Inscit. Menstruus, Vol. 4, 1916, p. 26.

Fabriciella montana Tns. Tothill, Can. Entom., Vol. 56, 1894, p. 259, 265.

Length, 10.1 mm. Parafrontals at the ocelli slightly wider than half the width of the frontal vitta, black polished except for a strip near the compound eye which is yellow pollinose, bearing numerous black hairs above and scattered black hairs toward the antennæ. Frontal vitta brownish-red, almost continuous width throughout. Frontals of irregular

size, fourteen to sixteen in number. Vertex shining black. Post-oculars ending before the ventral margin of the compound eye. Post-ocular region shining black except near the posterior ventral margin of the compound eye which is white pollinose. Narrowest width of the genæ slightly less than the length of the second antennal segment, brown in ground color, yellow pollinose, bearing many black hairs. Bucca for the most part polished brown, twice as wide as the genæ, and bearing many black hairs. Vibrissal ridges prominent. Vibrissæ only slightly larger than the bristles of the buccal row, which are large and numerous. Second segment of the antennæ longer than the third, brown; third segment black and showing tints of bronze under certain angles of light. Arista nearly as long as the second and third segments, heavy; second segment more than twice as long as wide. Mouthparts normal. Labial palpi dull yellow, slightly thickened distally. Proboscis from the articulation once and a half the length of the antennæ, brown.

Pleura polished black, hairy. Sternopleurals prominent. Notum black, polished, very hairy. Dorsocentrals not prominent. Scutellum brown, hairy, bearing many large marginals and few sub-marginals. Length of right wing, 9.8 mm. Legs dark brown, claws of the first as long as the last two tarsal segments.

Abdomen hairy, black except for a lateral orange spot on the first, second, and third tergites. Second tergite bearing three pairs of large lateral marginals, and three pairs of large median marginals.

Genitalia: (Plate II, Figure 9.) First genital segment (G1) dark brown to black, longer than the second genital segment (G2), bearing bristles on the lateral and dorsal surfaces. Second genital segment lighter than the first genital segment, bearing bristles and hairs on all surfaces. Accessory plates conspicuous brown, polished. Processes of the accessory plates (PAP) visibly short, round. Forceps (F) arched to the extent of about half its length, black and hairy. Beak caudally appearing long and straight, flat or slightly concave and very short acuminate. Anterior claspers (AC) larger and longer than the posterior claspers. Penis (P) extending far in front of the posterior clasper, chitinized portion prominent. Fifth sternite (5St) prominent heavily bristled. Cleft (C) wide at the bottom and narrow at the top appearing neck-like. Anal area (AA) very acute anteriorly and cutting deeply into the second genital segment.

Redescribed from two males: Male, Silverton, Colo., loaned by J. M. Aldrich, 1930. Male, Mt. Washington, collection of Mrs. A. T. Slosson, Ac. 26226; loaned by C. H. Curran, 1930.

Holotype: A male from White Mts., N. H., No. 19598 in U. S. Nat. Mus.

Other records: Male and female from White Mts., (Morrison), (B. & B. 55).

***Fabriciella latigena* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 262.

Length, 12 mm. Parafrontals at the ocelli slightly wider than half the length of the second antennal segment, ground color black, yellow pollinose. Frontal vitta narrower than parafrontals, reddish. Frontals large. Vertex dark. Ocellars large and curved obliquely forward. Post-ocular row distinct. Post ocular region covered with long white pile. Genæ wider than the length of the second antennal joint, yellow pollinose and bearing scattered black hairs below. Buccal region yellow, bearing small black hairs below, and bordered posteriorly by black hairs. Vibrissal ridge prominent, brownish, bearing few bristles above the vibrissæ. Vibrissæ large. Buccal row prominent. First and second segment of antennæ light brown, bearing small bristles. Third segment oblong, as long as second, black. Arista only slightly longer than the third antennal segment, second segment at least twice as long as wide. Arista abruptly tapering. Mouthparts normal. Labial palpi yellow, bearing small bristles on distal half, of a uniform width throughout. Proboscis black, chitinized portion once and a half as long as antennæ.

Pleura black, polished, sternopleurals three. Notum black, polished. Dorsocentrals four. Scutellum light brown, bearing three pairs of large marginals and one pair of weak marginals. Post-scutellum black in ground color, and white pollinose. Wings hayline. Length of right wing, 8.2 mm. Legs approaching black in color, all segments of legs except the tarsi bearing heavy bristles. Claws long, gently curved and spreading widely.

Abdomen yellow except for a black mid-dorsal stripe. Sternites bearing thick long weak bristles. Second tergite bearing two pairs of median marginals, and two pairs of lateral marginals. Genital segments prominent and black.

Genitalia: (Plate II, Figure 10.) Genital segments dark brown to black. First genital segment (G1) narrower than the second (G2), and bearing a few weak bristles. Second genital segment as wide as fifth sternite, and bearing weak bristles dorsally and black hairs laterally. Anal area (AA) large. Forceps (F) short but sharply pointed, and covered with short black hairs. Accessory plates (AP) conspicuous, a fourth as wide as the second genital segment. Processes of the accessory plates (PAP) curved, gradually tapering and about as long as the accessory plates. Fifth sternite (5St) broader than genitalia, and bearing numerous weak bristles on either side. Processes of the fifth sternite (P5St) hump like, not strongly chitinized. Posterior claspers (PC) slightly curving anteriorly, narrower and shorter than the anterior claspers. Anterior claspers (AC) abruptly pointed, heavier than posterior claspers. Penis (P) longer than either clasper, chitinized portion quite prominent.

Redescribed from a specimen bearing the label: Mt. Jefferson, Oregon. Determined by C. H. Curran, 1926. In the collection of the University of Utah.

Holotype: Male, Lillovet, B. C., 1917, 3,000 ft. (J. D. Tothill); No. 806 in the Canadian Nat. Collection, Ottawa.

Allotype: Female, Hedley, B. C., 1923 (C. B. D. Garrett).

Paratypes: Revelstoke Mt., B. C., 1923, (P. N. Vroom, R. Buchell); Hedley, B. C., 1923, (Garrett); Keremeose, B. C., 1923, (Garrett); Penticton, B. C., 1919, (Buchell); Lillovet, B. C., 1916, (A. W. Phair); Stein Mt. Dregon, 1922, (W. J. Chamberlin); Victor, Montana, 1918; Sparta, Oregon, 1922, (Chamberlin); Paratypes in the U. S. Nat. Museum and the California Academy of Sciences.

***Fabriciella latifacies* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 262.

Width of front at the ocellus equal to the eye width. Second antennal segment yellow, and longer than the third. Parafrontals opaque. Parafacials wider than the length of the second antennal segment. Genæ pollinose, with sparse mostly straw colored hairs. Probosis and palpi normal. Front tarsi not dilated, the claws as long as the last three tarsal segments. Front corners of the pronotum yellow. Abdomen yellow except for the shadow of a dorsal stripe on the first segment. Sternites and genital segments yellow.

Genitalia: (Plate II, Figure 11.) First genital segment (G1) brown, polished, bearing large bristles on all surfaces. Second genital segment (G2) brown, polished, unusually hairy on the ventral margin. Accessory plates (AP) prominent, polished. Processes of the accessory plates (PAP) round, quite narrow. Forceps (F) arched to the extent of over half its length, hairy. Beak of forceps (B) quite long its later ridges tapering gradually to the blunt tip. Posterior clasper (PC) heavier than the anterior clasper (AC). Penis (P) prominent. Cleft of the fifth sternite U-shaped, round on the bottom.

Redescribed from a single specimen loaned by C. H. Curran, 1931.

Holotype: Male, Ormsby Co., Nevada, July 6, (Baker); in the U. S. Nat. Museum.

Paratype: Male, Rogerson, Idaho, September 7, 1923, (Carl E. Duncan), reared from *Chrysothamnus*, in the Can. National Collection, Ottawa.

***Fabriciella canadensis* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 264.

"Width of frontal equal to one-half the eye width. Second antennal segment yellow and a little longer than the third. Parafrontals opaque. Narrowest width of parafacials slightly narrower than the front. Genæ pollinose with sparse black hairs above. Proboscis and palpi normal.

Front tarsi not dilated, the claws as long as the last two tarsal segments. Abdomen orange except for black dorsal vitta and fuscous sternites. Forceps strongly arched longitudinally, terminating in the usual broad shining somewhat concave plate." (Tothill's original description.)

Genitalia: (Plate II, Figure 12.) Dr. J. McDunnough has kindly furnished the following notes on the genitalia of the Holotype. "Forceps appear characteristic in having unusually dense, rather plumose hairs, especially along middle region beyond the slight concavity. This dense pilosity obscures the form of the posterior margin."

Holotype: Male, Godbout, Que., July 20, 1918, (E. M. Walker). No. 803, in the Canadian National Collection.

Paratypes: Male, same data as type; male, Nordegg, Alta., (J. McDunnough). In the Canadian National Collection. One male, same data as type in the U. S. National Museum.

***Fabriciella brevirostris* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 264.

Length, 12 mm. Parafrontals at the ocelli slightly wider than half the length of the second antennal segment, black near the vertex and yellow pollinose away from vertex, bearing no large bristles. Frontal vitta wider than half the length of the second antennal segment, blackish brown. Frontals medium large. Vertex black. Verticals large. Post-ocular row distinct. Post-ocular region covered with long white pile. Genæ wider than length of the second antennal segment, yellow pollinose and bearing scattered black hairs. Buccal region yellow pollinose, bearing scattered black hairs. Vibrissal ridge prominent, bearing bristles on at least its lower fourth. Vibrissæ median large. Buccal row prominent. First and second segments of antennæ light brown. Third segment oblong, dark brown to black, somewhat shorter than the second segment. Arista chocolate brown, tapering abruptly, second segment three times as long as wide. Mouthparts normal. Labial palpi yellow, of a uniform width, bearing small bristles on distal half. Proboscis unusually short, black chitinated part only slightly longer than the antennæ.

Pleura black, polished. Sternopleurals three. Notum black, polished. Dorsocentrals four. Scutellum dark brown, bearing three pairs of stout margins and three pair of weak marginals. Post-scutellum prominent and white pollinose. Wings hyaline. Length of right wing, 9 mm. Legs rather robust. Claws long and widely spread.

Abdomen foremost part yellow. Proximal half of first tergite, distal part of fourth, and mid-dorsal stripe, black. Second tergite of abdomen bearing one pair of median marginal and two pair of lateral marginal bristles. Genital segments prominent.

Genitalia: (Plate II, Figure 13.) Genitalia dark brown. First genital segment (G1) slightly smaller than the second (G2), bearing dorsally a few weak bristles and black hairs. Second genital segment somewhat inflated near the dorso-anterior margin, bearing scattered

black hairs. Anal area (AA) conspicuous. Forceps (F) about one-third as large as the second genital segment, very convex posteriorly, bearing short black hairs. Beak half as wide as forceps and gradually tapering. Accessory plate (AP) small somewhat hidden laterally by the second genital segment. Processes of the accessory plates (PAP) curved tusk-like, short, thick, tapering gradually, and sharply pointed. Fifth sternite (5St) slightly wider than the genital segments, deeply cleft, bearing weak bristles on lateral surfaces. Processes of the fifth sternite (P5St) short, blunt. Posterior claspers (PC) smaller than the anterior claspers (AC), projecting ventrally and curving gently anteriorly. Posterior claspers short and stout, knobbed on posterior margin, slightly hooked on the end, and bearing a few small hairs. Penis (P) longer than either clasper, chitinized and membraneous portions prominent.

Described from a single specimen in the collection of the University of Utah, bearing the label Crater Lake Nat. Park. Determined by C. H. Curran, 1930.

Distributional records: Crater Lake, Nat. Park.

Holotype: Male, Kereneos, B. C., 1922, (C. B. D. Garrett); No. 809 in the Canadian Nat. Collection, Ottawa.

Paratypes: Male, Vernon, B. C., (M. H. Ruhmann); Midday Valley, B. C., 1921, (G. Hopping); two males, Summit Mt. Lowe, California, July 4, (J. M. Aldrich); male, Mt. Lowe, 1917, (Aldrich); the last three in the U. S. Nat. Museum.

***Fabriciella nivalis* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 264.

"Width of the front equal to three-fourths the length of the second antennal segment. Second antennal segment dull amber or fuscous in color. Parafrontals opaque except at the vertex which is partly shining and black. Narrowest width of the parafacials equal to that of the front. Genæ pollinose with sparse black hairs above. Proboscis and palpi normal. Front tarsi not dilated; the claws as long as the last two tarsal segments. Abdomen black except for dull orange sides." (Description from Tothill).

Genitalia: (Plate III, Figure 14.) Dr. McDunnough's notes on the genitalia of the Holotype are as follows: "Forceps very heavily spinose except on the slightly concave face. The heavy bristles on forceps are interspersed with finer hairs. Posteriorly the bristles become longer and more dense obscuring the form of the posterior margin."

Holotype: Male, Healey, Alaska, June 7, 1921, (J. M. Aldrich). In the U. S. National Museum.

Allotype: Same data.

Paratypes: Seven males and 17 females, same data; in the U. S. National Museum and No. 802 in the Canadian National Collection.

***Fabriciella latianulum* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 266.

Length, 14.7 mm. Parafrontals at ocelli half as wide as the length of second antennal segment, yellowish-white pollinose, bearing numerous black hairs. Narrowest width of frontal vitta half as wide as length of second antennal segment, chocolate brown. Frontals large, twelve to fourteen in number. Vertex black. Post-oculars medium large. Post-ocular pile golden. Genæ two-thirds as wide as the length of the second antennal segment, yellow pollinose and bearing scattered black hairs above. Bucca yellow pollinose and bearing scattered black hairs. Vibrissal ridge not prominent. Vibrissæ very large and curved. Buccal row not intact, a few large bristles on the lower part. First and second segment of the antennæ chocolate brown, bearing few small bristles; third black, velvety, two-thirds as long as the second. Arista black, tapering gradually, second segment at least three times as long as wide. Mouthparts normal. Labial palpi thickened on the distal half, light brown. Proboscis black, chitinized part once and a third as long as antennæ.

Pleura black, polished. Sternopleurals five. Notum black, polished. Dorsocentrals four. Scutellum brown, bearing four pairs of marginals. Post-scutellum very prominent, black in ground color, white pollinose. Wing hyaline. Length of right wing, 11.6 mm. Legs very robust, black. Claws long, brown, hooked near the end.

Abdomen black, polished. Second tergite bearing one pair of median marginals and one pair of lateral marginals. First sternite bearing a thick cluster of short heavy bristles. Genital segments very conspicuous.

Genitalia: (Plate III, Figure 15.) Genital segments black, polished. First genital segment (G1) as wide as second genital segment (G2) bearing medium large bristles. Second genital segment black, polished, hairy, produced ventrally into a flap-like, truncate, heavily chitinized, process which bears a row of stout, blunt spines. Anal area (AA) very prominent. Forceps (F) curved, stout, bearing long black hairs. Accessory plate (AP) very small almost hidden completely by the forceps. Processes of the accessory plate (PAP) heavy, blunt, and curving hook-like. Fifth sternite (5St) broad, covered with long black hairs. Processes of the fifth sternite (P5St) blunt, and quite slender, about half as long as posterior claspers (PC). Posterior claspers short, straight, and projecting ventrally. Anterior claspers (AC) stout, larger and longer than posterior claspers, bluntly falcate on the end. Penis (P) smaller than the outer claspers, quite heavily chitinized. Genital sternum (GS) prominent, widening below the penis.

Redescribed from five males sent to me by J. Wilcox, Corvallis, Oregon, and determined by J. M. Aldrich, 1930.

Distributional records: Corvallis, Oregon, 1925, (J. Wilcox); Mary's Peak, Oregon, 1926, (J. Wilcox); Three Sisters, Oregon, 1926, (H. A. Scullen).

Holotype: Male, Royal Oak, B. C., June 30, 1917, (B. H. Tothill); No. 813 in the Canadian National Collection, Ottawa.

Allotype: Female, Agassiz, B. C., August 22, 1921, (R. Glendenning).

Paratypes: Males, same data as type, in the U. S. National Museum. Fifty males and females, Royal Oak, Victoria, Vancouver, Agassiz, B. C.; male, July, 1921, Larder Lake, Northern Ontario, (H. C. Cook).

***Fabriciella algens* (Wiedeman).**

Tachina algens Wd. Ausser. Zweif. Insekten, Vol. II, 185, *Tachina* N. A., 1830.

Nec. Echinomyia algens Wd. Coquillett's Rev. Tachinidae, p. 144, 1897.

Fabriciella algens Wd. Tothill, Can. Ento., Vol. 56, p. 260, 1924.

Length, 13.7 mm. Parafrontals at the ocelli over half as wide as the frontal vitta, yellow pollinose and bearing scattered black hairs. Frontal vitta of a continuous width, slate gray. Frontals large. Vertex yellow pollinose. Verticals very large. Post-ocular row prominent, running well past the ventral margin of the compound eye. Post-ocular pile yellow. Genæ as wide as the length of the second antennal segment, yellow pollinose and bearing black hairs. Bucca once and one-half longer than the genæ, polished brown on posterior third, and bearing numerous black and yellow hairs. Vibrissæ large. Buccal row very prominent. Second segment of the antennæ dark brown and only slightly longer than the third. Third segment from the profile nearly oval, black. Arista heavy, nearly as long as the second and third segments of antennæ, second segment nearly three times as long as wide. Mouthparts normal. Labial palpi yellow, much enlarged distally. Proboscis black, chitinized part only slightly longer than antennæ.

Pleura black, polished, lower sclerites free from dense bristles. Sternopleurals large. Notum black, polished, hairy. Dorsocentrals conspicuous. Scutellum slightly lighter in color than the notum; bearing five pairs of marginals, the third pair enormous in size. Length of right wing, 10 mm. Legs black, claws of the first as long as the last three tarsal segments.

Abdomen somewhat cone-shaped, black above and lighter on the sides, polished. Second segment bearing one pair of median marginals and two pairs of lateral marginals. Second sternite thickly set with short stout spines. Genital segments unusually large.

Genitalia: (Plate III, Figure 16.) Genital segments black. First genital segment (G1) longer than the second genital segment (G2) bearing bristles only on the lateral surfaces. Second genital segment produced ventrally into a club shaped flap which is highly polished and bears a row of short, heavy, spines arranged in comb-like fashion on

the lateral margin. Accessory plates (AP) hidden, from the side, by second genital segment. Processes of the accessory plates (PAP) flat, angularly curved. Forceps (F) arched to the extent of over half its length, black hairy. Beak (B) short and quite curved. Claspers long and thin. Fifth sternite quite small, heavily bristled, black. Cleft (C) as deep as half the length of the fifth sternite, acute at the bottom gradually widening toward the center and narrowing again at the top thus giving it a diamond shaped appearance. Processes of the fifth sternite reflected inward.

Redescribed from a series of four males in the collection of the University of Utah, determined by J. M. Aldrich, 1930.

Distributional records: Ringwood, Tompaine Co., N. Y., 1928, (H. A. Scullen); Lewis Lake, Yellowstone National Park, (V. M. Tanner); Fish Lake, June 17, 1926; Ithaca, N. Y., July, 1928, (H. A. Scullen); Carbon Co., Wyoming; Smiths Cove, N. S.; Salisbury and Fredericton, N. B.; Hastings, Trenton, Sudbury, Ottawa, Rainy River District, Ontario; Northwest Territories; Mt. Cheam, Agassiz, Penticton and London Hill Mine, B. C.; Franconia, New Hampshire.

***Fabriciella spineiventer* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 266.

Length, 12 mm. Parafrontals at the ocelli as wide as the frontal vitta, dark in ground color, yellow pollinose, and bearing few scattered small black hairs. Frontal vitta of a continuous width, maroon in color. Frontals large. Vertex black. Verticals large. Post-ocular row prominent, ending before reaching the buccal region. Post-ocular pile long and golden. Genæ slightly narrower than twice the width of the frontal vitta, yellow pollinose, bearing few black hairs on the lower third. Bucca wider than genæ, yellow pollinose, and bearing scattered black and yellow hairs. Vibrissæ prominent. Vibrissal ridge only sub-prominent. Buccal row not intact, only a few large bristles at the lower margin. Antennæ (the antennæ were missing on the only specimen available. Labial palpi yellow, distinctly thickened on the distal end, bearing short black bristles. Chitinized portion of proboscis longer than labial palpi.

Pleura chocolate brown, polished. Sternopleurals three. Notum dark brown to black, polished, dorsocentrals four. Scutellum lighter in color than the thorax proper, bearing three pairs of marginal bristles, and two pairs of sub-marginal bristles. Wings hyaline. Length of right wing, 9.6 mm. Legs chocolate brown.

Abdomen narrower than the thorax, conical, chocolate brown and highly polished. Second tergite bearing one pair of median marginals and two pairs of lateral marginals. Second and third sternites bearing thick clusters of short stout bristles. Fourth tergite bearing numerous large bristles, especially on the ventral surface. Genital segments very prominent, hairy, chocolate brown to black.

Genitalia: (Plate III, Figure 17.) Genital segments very pronounced. First genital segment (G1) fully as long as the second genital segment (G2), but somewhat narrower, bearing medium large bristles on dorsal and lateral surfaces. Second genital segment appearing oval from the side, somewhat inflated near the antero-dorsal margin, ventral margin produced outward in the form of a ridge bearing a cluster of short stout spines. Accessory plates (AP) indistinct, almost hidden by the forceps (F). Forceps small, only about one-sixth as large as second genital segment. Beak short, dorsal margin sharply ridged. Dorsal and lateral surfaces of forceps densely covered with black hair. Anal area (AA), large, almost reaching one-third the length of the second genital segment. Processes of the accessory plates (PAP) flat, robust, about as long as posterior claspers and bearing fine yellow hair on the inner surface. Posterior claspers (PC) well developed, slightly curved and thickened on the end, slightly longer than anterior claspers. Anterior claspers (AC) well developed and slightly hooked on the end. Chitinized part of penis (P) as wide as the width of posterior claspers, membranous part, more than half as long as posterior claspers. Fifth sternite (5St) conspicuously prominent, cleft shallow, all surfaces of sternite bearing medium large bristles and black hairs. Processes of fifth sternite (P5St) about half as long as depth of cleft.

Redescribed from a single male paratype labeled Moscow, Idaho, (J. M. Aldrich); loaned to me and determined by Dr. J. M. Aldrich, 1930.

Holotype: Male, Mt. McLean, B. C., 8,000 ft., 1917, (J. D. Tothill); No. 812 in the Canadian Nat. Collection, Ottawa.

Paratypes: Male, Moscow, Idaho, (J. M. Aldrich); in the collection of J. M. Aldrich. Male, Vancouver, B. C., 1923, (D. E. Osburn).

***Fabriciella latifrons* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 260.

Length, 12.7 mm. Parafrontals at ocelli slightly more than half as wide as the frontal vitta, for the most part polished black, bearing scattered black hairs. Frontal vitta of a continuous width, dark reddish-purple. Frontals large, the row nearly reaching the compound eye. Vertex black in ground color, white pilose in intermittent spots. Verticals conspicuous. Post-ocular row running well past the ventral margin of the compound eye. Post-ocular region white pollinose. Post-ocular pile golden. Genæ at its narrowest width about two-thirds the length of the second antennal segment, yellow pollinose and bearing a few scattered black hairs. Bucca fully twice as wide as the genæ, yellow pollinose and bearing scattered black and yellow hairs. Buccal row prominent. Vibrissal ridge polished brown, bearing only two or three bristles above the vibrissæ. Vibrissæ very heavy. Second segment of the antennæ dark brown or black. Third segment black

and appearing from the side nearly oval. Arista two-thirds as long as the combined length of the second and third antennal segments, gradually tapering, second segment nearly three times as long as wide. Mouth parts normal. Labial palpi light brown, much thickened distally. Proboscis black, a third longer than the antennæ.

Pleura black, polished. Sternopleurals three, prominent. Notum black, polished, and quite hairy. Dorsocentrals medium large. Scutellum slightly lighter in color than the notum, bearing five pairs of marginals and several submarginals. Length of right wing, 8.7 mm. Legs black. Claws of the third only slightly longer than the last tarsal segment.

Abdomen black, polished. Second tergite bearing a pair of median marginals and a pair of lateral marginals. Bristles of the fourth tergite very stout.

Genitalia: (Plate III, Figure 18.) All genital segments black, bearing few or no large bristles. First genital segment (G1) hairy but bearing few or no bristles. Second genital segment very large, many times larger than forceps (F), anterior margin much wider than posterior margin, hairy. Accessory plates reduced, hidden laterally by second genital segment, its processes (PAP) only half exposed, and flat on the inner surface. Anal area (AA) small, oblong oval. Forceps small, black, its beak (B) becoming unusually short and truncate. Posterior claspers curved greatly, about the same length as the anterior claspers. Penis (P) short and heavy, projecting portion several times larger than the anterior claspers (AC). Fifth sternite (5St) characteristically narrowed posteriorly, its cleft (C) being shallow and U-shaped, its processes (P5St) being prominent.

Original diagnosis by Tothill only in his key to species. He does not publish data as to types and their location. Holotype apparently in Can. Nat. Coll., Ottawa.

Redescribed from a paratype male, Aweme, Man., VII-28, 1920, H. A. Robertson; No. 811 in the American Museum of Natural History. Kindly loaned to me by Dr. C. H. Curran.

Distribution records: Hedley, B. C., 1923, C. B. Garrett; Aweme, Man., 1920, H. A. Robertson; N. W. T.; S. D. and Colo., *vide* Tothill, (loc. cit., p. 269).

***Fabriciella rostrata* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 267.

Length, 14.5 mm. Vibrissal ridge prominent and bearing few bristles above the vibrissæ. Vibrissæ very large. Buccal row prominent. Genæ and facial depression, yellow pollinose. Buccal region bearing scattered black and yellow pile. Front wider than the length of the second antennal segment. Parafrontals dark and bearing several strong bristles. Frontals nine to twelve in number. Ocellars pointing obliquely forward. Post-ocular row distinct. Post-ocular region covered with long yellow pile. First two segments of antennæ chocolate

brown, third segment black, except at the point of attachment which is reddish brown. Arista long and tapering, its second segment twice as long as wide. Mouth parts normal. Labial palpi well developed, yellowish brown, and bristled on the distal end. Proboscis black, one and a third times as long as the total length of the antennæ.

Pleura and notum polished. Dorsocentrals four. Sternopleurals three. Post-scutellum lighter in color than the notum, bearing three pairs of strong marginals and one pair of weaker marginals. Legs rather robust, black. Tarsal claws well developed, yellowish, darkening toward the tip. Wings hyaline. Length of right wing, 11 mm.

Abdomen black, convex dorsally, polished. Second tergite bearing one pair of heavy median marginals, a single pair of lateral marginals. Sternites all bearing heavy bristles. Genitalia conspicuously prominent.

Genitalia: (Plate III, Figure 19.) First genital segment (G1) prominent, black and bearing weak bristles on the dorsal and latero-dorsal surface. Second genital segment (G2) very prominent, black, polished, bearing small bristles on all surfaces. Forceps (F) characteristically shaped like the head of a chicken. Accessory plates (AP) small, almost hidden by forceps and second genital segment. Processes of the accessory plates (PAP) many times longer than forceps and curving tusk-like, abruptly acuminate. Fifth sternite (5St) prominent, bearing weak bristles near the sternal processes. Process of fifth sternite (P5St) medium long, bluntly rounded at the tip. Posterior claspers (PC) nearly as long as the anterior claspers (AC), and gently curving toward them. Anterior claspers as long as visible portion of the penis (P) pointing anteriorly and heavily chitinized.

Redescribed from a series of 14 males in the collection of the University of Utah. Determined by Dr. J. M. Aldrich, 1930.

Distributional records: Cedar City, Utah, 1919, (H. R. Hagan); Vancouver, Washington, 1911, (M. W. Reeves).

Holotype: Male, Penicton, B. C., 1913, (E. M. Anderson); No. 814 in Canadian Nat. Collection, Ottawa.

Allotype: Female, Hedley, B. C., 1923, (C. D. Garrett).

Paratypes: Male, Grow Agency, Montana, (R. Kellogg); male, Okanagan, B. C., (T. Wilson); male, Mt. McLean, B. C., (A. W. Phair); male, Dunvegan, Alta., (E. H. Strickland); two males, Lethbridge, Alta., 1921, (E. H. Strickland); four males, Lethbridge, Alta., 1921, (H. L. Seamans); male, Lethbridge, 1921, (W. Carter); two males, Baniff, Alta., 1922, (Garrett); four males, Hedley, B. C., 1923, (Garrett).

***Fabriciella nitida* van der Wulp.**

Jurinia nitida v. d. W. Notes from the Leyden Mus., Vol. 4, p. 82, 1882.

Fabriciella nitida v. d. W. Tothill, Can. Ento., Vol. 56, p. 268, 1924.

Length, 13 mm. Head wider than long. Parafrontals at the ocelli slightly more than half as wide as the length of the second antennal

segment, black polished along a strip on each side of the frontal row, yellow pollinose on a strip near the eye. Frontal vitta reddish, light pollinose, wider than half the length of the second antennal segment. Ocellars medium large, and pointing obliquely forward. Post-ocular row prominent. Post-ocular pile yellow. Frontals prominent, curving inward and nearly reaching the eye. Genæ narrower than second antennal segment, yellow pollinose, and bearing a few weak hairs. Bucca golden pollinose, darkening ventrally, bearing a few weak hairs. Vibrissal ridges prominent, and bearing few bristles above vibrissæ. Vibrissæ large. Buccal row intact, lower bristles large. First and second segment of the antennæ dark brown; third segment black, large, and ax-blade shaped. Arista long and tapering abruptly, black, combined length of first and second segments nearly equal to that of the third. Mouthparts normal. Labial palpi rather short, stout, yellow, and bearing short spines. Proboscis long, slender, and black.

Pleura black and polished, its sclerites bearing numerous heavy bristles and long black pile. Sternopleurals three. Notum black, polished. Dorsocentrals four. Scutellum dark brown, bearing three pairs of large marginals and one pair of weak marginals. Post-scutellum faintly white pollinose. Wings hyaline. Length of right wing, 11 mm. Legs robust, black. Claws long, and darkening near the tip.

Abdomen black and polished. Second tergite bearing one pair of median marginal and one pair of lateral marginal bristles. Genital segments very prominent.

Genitalia: (Plate IV, Figure 20.) Genital segments black and polished. First genital segment (G1) as wide as the second genital segment (G2), bearing scattered long black hairs. Second genital segment inflated dorsally near the anterior margin, tapering posteriorly, bearing scattered black hairs dorsally and thick black hairs on the ventro-lateral margins. Anal area (AA) large. Forceps (F) well developed, and constricted in the middle, covered dorsally and laterally by long black hairs. Accessory plates (AP) small, hidden laterally by second genital segment. Processes of the accessory plates (PAP) about as long as anterior claspers, curved inward and toward the forceps, sharply pointed and tapering gradually. Fifth sternite (5St) broad, bearing thickly set medium large bristles ventrally and black hairs laterally. Processes of the fifth sternite (P5St) blunt, curving gently dorsally. Posterior claspers (PC) shorter than the anterior claspers (AC), about the same width. Posterior claspers with a large base, gently hooked on the end. Penis (P) longer than either clasper, chitinized portion prominent, membranous portion long. Genital sternum inconspicuous.

Types in Leyden Museum.

Redescribed from a single specimen sent to the author by J. Wilcox, Corvallis, Oregon, and determined by J. M. Aldrich, 1930.

Distributional records: Anthony Lake, Oregon, 1929, (H. A. Scullen); Fort Bridge, Wyo., 1926, (C. Cottam); British

Columbia; Colorado; Toronto, Canada; White Mountains and Franconia, N. H.; Vermont; New Bedford, Mass.; Oswego, N. Y.; Montana; Washington; California.

***Fabriciella latiforceps* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 266.

Length, 13 mm. Parafrontals at the ocelli half as wide as the frontal vitta, black above and yellow pollinose, below bearing scattered black hairs. Frontal vitta widening as it approaches the antennæ. Frontal row sub-prominent. Vertex and dorsal half of the post-ocular region polished black. Verticals medium long. Post-ocular row reaching the ventral margin of the compound eye. Post-ocular pile yellow. Narrowest width of genæ equal to four fifths of the second antennal segment, yellow pollinose and bearing scattered black hairs. Bucca more than twice as wide as the genæ, thinly pollinose on the anterior half and bearing many black hairs. Facial ridges prominent, light brown. Vibrissæ only medium large. Buccal row inconspicuous. Second segment of the antennæ brown, almost twice as long and nearly as wide as the third. Third segment black, quite small. Arista heavy, tapering gradually, second segment slightly more than twice as long as wide. Mouthparts normal. Labial palpi yellow, enlarged distally. Chitinized part of proboscis no longer than antennæ.

Pleura polished black. Sternopleurals medium large. Notum polished black. Dorsocentrals small, four. Scutellum slightly lighter in color than the notum, bearing four pairs of marginals and few or no sub-marginals. Length of right wing, 10.6 mm. Legs black. Claws of the first nearly as long as the last two tarsal segments.

Abdomen black dorsally, lighter laterally, polished. Second tergite bearing two pairs of median marginals, and two pairs of lateral marginals.

Genitalia: (Plate IV, Figure 21.) Genital segments sub-prominent, brown except the forceps which are black. First genital segment (G1) bearing few or no large bristles, darker than the second genital segment (G2). Second genital segment from the side appearing no more than four times as large as the forceps, brown, bearing few or no large bristles. Accessory plate (AP) distinct, but appearing reduced. Anal area (AA) extremely large, acute on margin opposite forceps. Forceps (F) black, hairy, arched to almost the extent of half its length. Beak (B) broad, concave and short acuminate. Processes of the accessory plates (PAP) round. Anterior claspers (AC) heavier and longer than the posterior claspers (PC). Posterior claspers nearly straight. Membranous portion of the penis (P) prominent. Fifth sternite (5St) black, bearing many bristles. Cleft (C) distinctly V-shaped.

Redescribed from a single male specimen, Mt. Katahdin, Me., Camp Kennedy, 3,000 feet, August, 1902; determined and sent to me by J. M. Aldrich, 1930.

Holotype: Male, Gadbout, Quebec, July 25, 1918, (E. M. Walker); No. 804 in the Canadian National Collection.

Paratypes: Male, same data as holotype, in the U. S. Nat. Museum; Banff, Alta., June 30, 1922, (C. B. D. Garrett); male, Mt. Revelstoke, B. C., August 12, 1923, (E. R. Buckell). In the Canadian National Collection.

***Fabriciella emarginata* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 260.

Length, 14.5 mm. Parafrontals at the ocelli narrower than half the length of the second antennal segment reddish. Post-ocular row distinct, reaching the buccal region. Post-ocular pile yellow. Genæ as wide as half the length of the second antennal segment, yellow pollinose, reddish in ground color, bearing scattered black hairs. Buccal region as wide as length of second antennal segment, reddish in ground color, yellow pollinose. Vibrissæ very large. Vibrissal ridge prominent on at least the upper half. First and second segments of the antennæ dark brown; third segment black, laterally sub-quadrate. Arista black, long, tapering gradually; second segment at least three times as long as wide. Mouthparts normal. Labial palpi yellow, narrowing slightly toward the base. Chitinized portion of the proboscis slightly longer than the combined length of the last two antennal segments.

Pleura dark brown to black, polished. Sternopleurals four. Notum black except at the margins which are dark brown. Dorsocentrals four. Scutellum dark brown, bearing five pairs of large marginals and three pairs of large sub-marginals. Wings hyaline. Length of right wing, 10.7 mm. Legs robust, black except for the tibia of the second and third which are distinctly brown. Claws long, and black tipped.

Abdomen dark brown except on the mid-dorsal line where the color is nearly black. Second tergite bearing a pair of large median marginals and three pairs of large lateral marginals. Third tergite bearing a row of large marginal bristles. All sternites bearing medium large bristles. Genital segments, sub-prominent and brown.

Genitalia: (Plate IV, Figure 22.) Genital segments highly polished, chocolate brown. First genital segment (G1) slightly smaller than the second genital segment (G2), acutely angled on the ventral margin, bearing medium large scattered bristles on the dorsal surface. Second genital segment somewhat inflated at the dorso-anterior margin, bearing black hairs on all surfaces and a few medium large bristles on the dorsal surface. Accessory plates (AP) quite conspicuous except at the ventral margins where they are hidden by the second genital segment. Processes of the accessory plates (PAP) short, curved, convex on the external surface, flat on the inner surface. Forceps (F) ventrally flat, sharp pointed, somewhat disc-shaped, upper portion bearing thickly set long black hairs. Posterior claspers (PC) longer, and as stout as the anterior claspers (AC) and curved anteriorly. Anterior claspers (AC) projecting ventrally and anteriorly respectively, slightly curved at the tip, and expanded near the middle. Penis (P) much longer than either clasper, chitinized portion very prominent, projecting below the anterior clasper; membranous portion very conspicuous about as long as the

distal half of the anterior clasper. Fifth sternite (5St) broader than the genital segments. Processes of the fifth sternite (P5St) knob-like and bending laterally, heavily chitinized. Cleft (C) characteristically U-shaped.

Redescribed from a single specimen sent to me and determined by Dr. J. M. Aldrich, 1930.

***Fabriciella piceifrons* (Townsend).**

Echinomyia algens Coquillett (nec. *Tachina algens* Wied), Rev. Tach., 1897, p. 144.
Echinomyodes piceifrons Townsend, Insec. Inscit. Menstruus, Vol. 4, 1916, p. 25.
Fabriciella piceifrons Tns., Tothill, Can. Ent., Vol. 56, 1924, p. 265.

Length, 15.8 mm. Parafrontals at the ocelli less than one-half the width of the frontal vitta, shining black, bearing numerous black hairs. Frontal vitta at its narrowest width three-fourths as long as the second antennal segment. Frontals prominent. Vertex dark, pollinose in certain regions. Post-ocular row prominent, running well into the buccal cavity. Post-ocular pile golden. Narrowest width of the genæ two-thirds the length of the second antennal segment, yellow pollinose and bearing scattered black hairs. Buccæ at least twice as wide as the genæ, for the most part shining brown, and bearing numerous black hairs. Vibrissal ridges prominent. Vibrissæ only slightly more prominent than the bristles of the buccal row. Second segment of the antennæ one-third longer than the third, dark brown; third segment black, except near the joint which is brown, quite truncate. Arista two-thirds as long as the combined length of the second and third antennal segments, thin on the apical half, second segment three times as long as wide. Mouthparts normal. Labial palpi light brown. Proboscis from the articulation one-fourth longer than antennæ.

Pleura black, polished. Sternopleurals large. Notum black, polished. Dorsocentrals large. Scutellum as dark as notum, bearing four pairs of very large marginals and numerous sub-marginals. Length of right wing, 10.7 mm. Legs dark brown or black, bearing many large bristles, claws of the first longer than the last two tarsal segments.

Abdomen dark brown, lighter ventrally, bearing numerous heavy bristles. Second tergite bearing one pair of large medium marginals, and two pairs of large lateral marginals.

Genitalia; (Plate IV, Figure 23.) Genital segments except the forceps dark brown. First genital segment (G1) about equal to the second genital segment (G2). Bristles on the dorsal surface. Second genital segment inflated on the dorsal surface, and bearing bristles on all surfaces. Accessory plates (AP) almost hidden by the second genital segment. Anal area (AA) large, acutely angled opposite the forceps. Forceps (F) black, arched to half its length, very hairy. Beak (B) flat, acutely pointed, somewhat concave dorsally. Processes of the accessory plates (PAP) with tips touching, flat on inner surface. Fifth sternite brown, very bristly, its cleft (C) deep and wide at the bottom, almost quadrate, processes of the fifth sternite (P5St) prominent and reflected outward.

Redescribed from two males: Springfield, Mass., (G. Dummock), No. 11138 in Dummock's Entomological Notes, sent to me by Dr. J. M. Aldrich, 1930. Platte, 8.16 : 77, (Curran collection) sent to me by C. H. Curran, 1930.

Holotype: A female from Vermont, No. 19597 in U. S. Nat. Mus.

Distributional records: Trenton and Sudbury, Ontario; Northwest Territories; Melrose Hylands, Mass.; Uinta National Forest Park, Utah; and Morrison, Colorado.

***Fabriciella hispida* Tothill.**

Canadian Entomologist, Vol. 56, 1924, p. 265.

Length, 14.4 mm. Parafrontals at the ocelli narrower than half the length of the second antennal segment, yellow pollinose and bearing scattered black hairs. Frontal vitta of a continuous width, more than half as wide as the length of second antennal segment, maroon. Frontals medium large. Vertex black, polished. Verticals large. Post-ocular row distinct, ending above the ventral margin of the compound eye. Post-ocular pile golden. Genæ wider than half the length of the second antennal segment, golden pollinose, bearing a few small black hairs. Buccal region as wide as the length of the second and third antennal segments, golden pollinose, bearing scattered black and yellow hairs. Vibrissæ medium large. Vibrissal ridges distinct, prominent on at least the upper half. First and second segments of the antennæ light brown, bearing small bristles; third black, laterally sub-quadrate, not more than half as long and once and a half as wide as the second segment. Arista brown, small, tapering gradually; second segment three times as long as wide. Mouthparts normal. Labial palpi slightly longer than the antennæ. Proboscis slender, chitinated part once and a third as long as the antennæ.

Pleura dark brown, polished. Sternopleural bristles four. Notum black, polished. Dorsocentrals four. Scutellum brown, bearing four pairs of large marginals and three pairs of large submarginals. Post-scutellum large, black. Wings hyaline. Length of right wing, 11.5 mm. Legs chocolate brown, all segments bearing numerous bristles. Claws small yellow.

Tergites chocolate brown except at the mid-dorsal line where they are black. Sternites chocolate brown, bearing numerous medium large bristles. Second tergite bearing three pairs of large median marginals, and five pairs of lateral marginals. Third tergite with a conspicuous row of large marginal bristles. Genital sub-prominent.

Genitalia: (Plate IV, Figure 24.) Genital segments black or brown in color. First genital segment (G1) black, polished, acutely angled ventro-anteriorly, bearing medium large bristles on the dorsal and lateral surfaces. Second genital segment (G2) black on the dorsal surface and distinctly brown on the lateral, projecting over the accessory plate on the ventro-posterior region, bearing medium large bristles on

only the dorsal surface. Accessory plates (AP) prominent from the ventral and posterior aspect, partly hidden from the lateral view, brown. Processes of the accessory plates (PAP) round, curved tusk-like and medium long, bearing a few brown hairs on the inner surface. Forceps (F) black, polished, horizontal diameter much less than that of the second genital segment, somewhat inflated on the medio-posterior region, thickly beset with black hair giving a tufted appearance. Beak (B) of forceps sharp pointed and flat. Ventrally appearing shield shaped. Anal area (AA) prominent, diamond shaped. Posterior clasper (PC) brown, about as long as the distal half of the anterior clasper (AC) gently curved and bluntly tipped. Anterior clasper (AC) brown, projecting posteriorly and ventrally respectively; ventral projection inflated near the middle and somewhat hooked on the end, bearing a few scattered yellow hairs. Penis (P) longer than either clasper, membranous portion characteristically dark in color. Fifth sternite (5St) broader than genital segments, chocolate brown, lateral surfaces bearing numerous closely set medium large bristles. Processes of the fifth sternite (P5St) at least half as deep as the length of fifth sternite, V-shaped.

Redescribed from a single specimen loaned to me and determined by Dr. J. M. Aldrich, 1930.

Holotype: Male, Sudbury, Ont.; Ottawa, No. 805 in the Canadian Nat. Collection.

Allotype: Female, same data.

Paratypes: Three males, same data as type; one female, northern Ontario; male, Kentville, N. S.; male, Frederickton, N. B., (J. D. Tothill); male, Hastings Co., Ont., (Evans); in the Canadian Nat. Collection, Ottawa.

***Fabriciella ampliforceps* n. sp.**

Length, 15.2 mm. Front wider than the length of the second antennal segment. Parafrontals at the ocelli, narrower than the half of the width of the frontal vitta, yellow pollinose and bearing numerous black hairs. Post-ocular region yellow pollinose. Post-ocular pile golden. Narrowest width of the genæ equal to two-thirds the length of the second antennal segment, yellow pollinose and bearing many black hairs. Bucca yellow pollinose and bearing both black and yellow hairs. Vibrissal ridges distinct and polished brown. Second segment of the antennæ light brown; third somewhat quadrangular, two-thirds as long as the second. Arista heavy, almost as long as the combined length of the last two segments of the antennæ.

Pleura black and polished. Sternopleurals five. Notum polished black, except on the humeral callæ which is thinly white pollinose. Dorsocentrals four. Scutellum slightly lighter than the notum, with four pairs of marginals and three pairs of submarginals. Last segment of the tarsi bearing numerous long bristles. Pulvilli greatly developed, almost as long as claws.

Abdomen black and polished. Apical tergites with numerous long bristles. Sternites with thickly set long bristles. Second tergite with four pairs of median marginals, and five pairs of lateral marginals.

Genitalia: (Plate IV, Figure 25.) Genital segments dark brown to black. First genital segment (G1) polished, as large as the second genital segment (G2) and with few or no large bristles. Second genital segment lighter, and with few or no large bristles. Accessory plates triangular, with the apex dorsally. Processes of the accessory plates (PAP) normally hidden by the ventral margins of the second genital segment. Forceps (F) laterally appearing at least one-third as large as the second genital segment, elongated. Beak (B) with short parallel ridges and medium large acuminate tip. Anal area (AA) large. Posterior clasper (PC) almost straight. Anterior clasper (AC) regular. Cleft of fifth sternite (C) U-shaped, round on the bottom.

Holotype: Male, Mahone Bay, 9, viii, C. A. Hamilton; in the Canadian National Collection, Ottawa.

Paratype: Male, Cowley, Alta., 20, vi, 1918, R. N. Christal; in the collection of the University of Utah, Salt Lake City.

BIBLIOGRAPHY.

1. Aldrich, J. M. 1916. Sarcophaga and Allies. Vol. I, Say Foundation.
2. Aldrich, J. M. 1905. A Catalogue of North American Diptera. Smithsonian Misc. Coll. XLVI. No. 1444.
3. Bezzi, M. Noch einige neuen Namen für Dipterengathungen. Teitschr. of Syst. Hymenopterologie u. Dipterologie, Vol. 6, 1906, pp. 49-55.
4. Brown, C. J. D. 1928. A Morphological and Systematical Study of Utah Asilidae. Trans. Am. Ent. Soc., Vol. LIV, pp. 295-320.
5. Coquillett, D. W. 1887. Revision of the Tachinidae of America North of Mexico. U. S. Dept. of Agriculture. Tech. Bull. No. 91.
6. Crampton, G. C. 1918. The Genitalia and Terminal Abdominal Structures of Male Neuroptera and Mecoptera with Notes on the Psocidae, Diptera and Trichoptera. Psyche, Vol. XXV, June, 1918.
7. Curran, C. H. 1925. Canadian Entomologist, Vol. 57, p. 256.
8. Panzer. Faunae Insectorum Germaniae Initia, 1809.
9. Robineau-Desvoidy. Essai sur les Myodaires, 1830.
10. Tothill, J. D. 1924. A Revision of the Nearctic Species in the Genus Fabriciella (Tachinidae). Can. Ent., Vol. 56, 1924.
11. Townsend, C. H. T. Notes on North American Tachinidae, sens. str., with Descriptions of New Genera and Species. Trans. Amer. Ent. Soc., XIX, 1892, pp. 82-132.
12. Townsend, C. H. T. Elucidation of New England Muscoidea. Insecutor Inscitiae Menstruus, Vol. 4, 1916, pp. 17-33.
13. Walker. Walker's List No. IV, 722. 1849.
14. Wiedemann. Aussereuropäische Zweiflügelige Insecten, 1830.
15. Wulp, F. M. Van der. Notes from the Leyden Museum, IV, 1882, p. 82.

EXPLANATION OF ABBREVIATIONS.

F.....forceps
AA.....anal area
AP.....accessory plates
PAP, processes of the accessory plates
G1.....first genital segment
G2.....second genital segment
PC.....posterior claspers
AC....,.....anterior claspers

GS.....genital sternum
P.....penis
Sp.....spiracle
M.....membrane
4Tg.....fourth tergite
5 St.....fifth sternite
C.....cleft of the fifth sternite

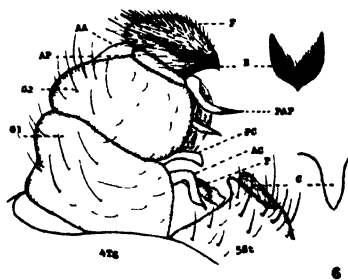
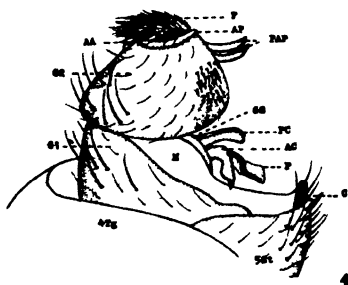
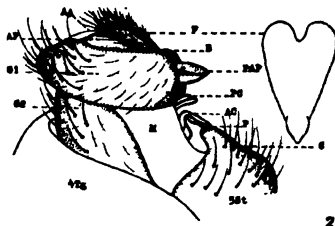
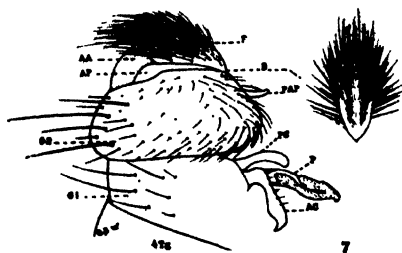
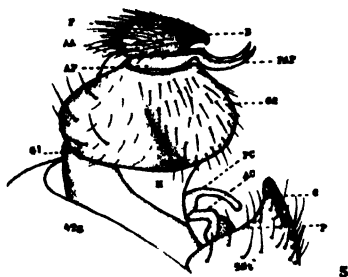
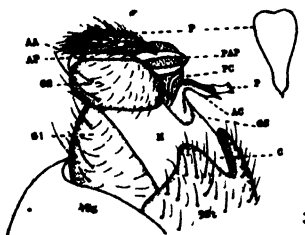
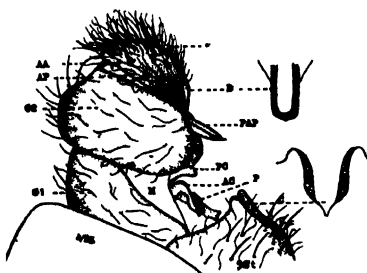
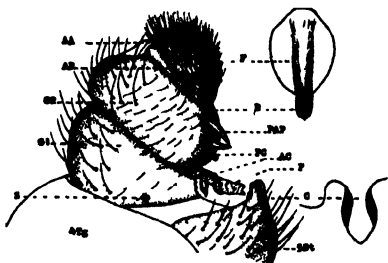


FIG. 1. *Fabriciella acuminata* Tot.
FIG. 2. *Fabriciella cordiforceps* n. sp.
FIG. 3. *Fabriciella florum* Wlk.
FIG. 4. *Fabriciella spinosa* Tot.

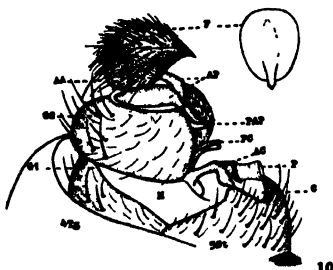
FIG. 5. *Fabriciella lutzi* Curr.
FIG. 6. *Fabriciella argentia* n. sp.
FIG. 7. *Fabriciella longiunguis* Tot.



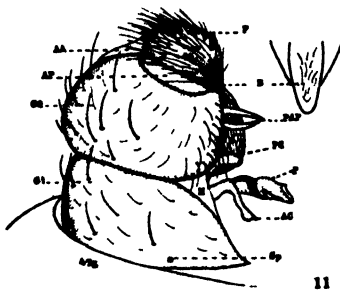
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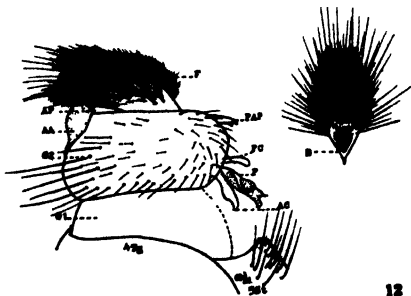
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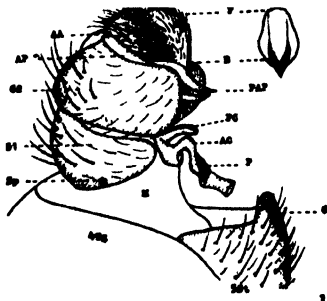
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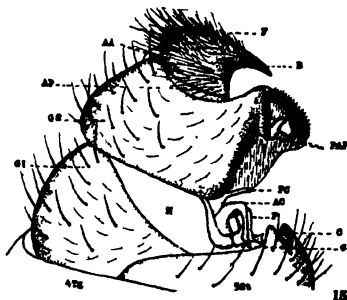
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FIG. 8. *Fabriciella pilosa* Tot.
FIG. 9. *Fabriciella montana* Tns.
FIG. 10. *Fabriciella latigena* Tot.

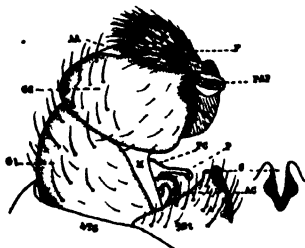
FIG. 11. *Fabriciella latifacies* Tot.
FIG. 12. *Fabriciella canadensis* Tot.
FIG. 13. *Fabriciella brevirostris* Tot.



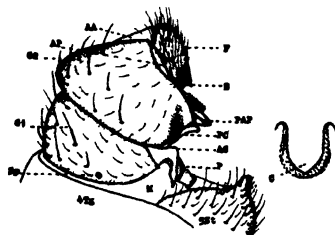
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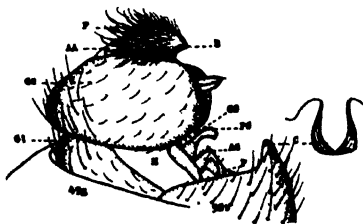
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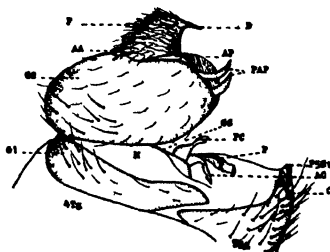
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FIG. 14. *Fabriciella nivalis* Tot.
FIG. 15. *Fabriciella latianulum* Tot.
FIG. 16. *Fabriciella algens* Wd.

FIG. 17. *Fabriciella spineiventer* Tot.
FIG. 18. *Fabriciella latifrons* Tot.
FIG. 19. *Fabriciella rostrata* Tot.

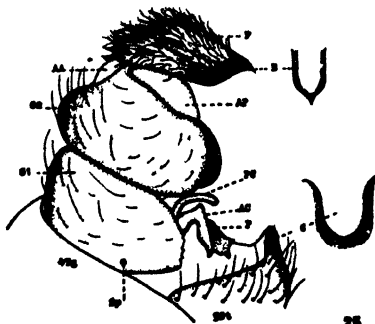
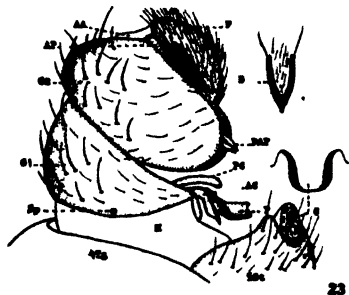
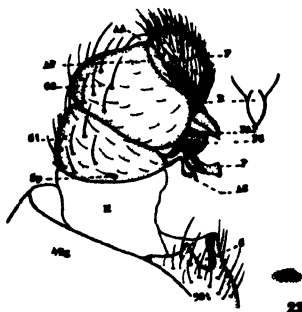
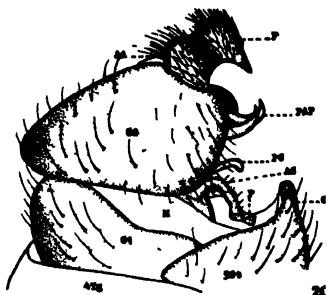


FIG. 20. *Fabriciella nitida* v. d. W.
FIG. 21. *Fabriciella latiforceps* Tot.
FIG. 22. *Fabriciella emarginata* Tot.

FIG. 23. *Fabriciella piceifrons* Tns.
FIG. 24. *Fabriciella hispida* Tot.
FIG. 25. *Fabriciella ampliforceps* n.sp.

ANNALS
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No. 4

**EARLY WORK AND WORKERS IN AMERICAN
HEMIPTEROLOGY.**

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Although isolated species of American Hemiptera had been previously described by Linnaeus and others, the real beginning upon the American fauna must be considered as dating from the work of the Danish entomologist, Fabricius, a student under Linnaeus, appearing in the "Systema Entomologia" (1775) and later collected and amplified with many additional species into the "Systema Rhynqotorum" (1803).

The Fabrician species, numerous as they are, and mostly described in the briefest terms are, nevertheless, usually placed with a high degree of certainty, a fact which is in some cases due to the efforts of Stål presented in the "Hemiptera Fabriciana" (1868-9), in which location of type material is indicated. His reference to "America Septentrionale" and "America Meridionale," of very frequent occurrence, though very indefinite according to present standards, may usually be defined for different species.

The next great advance after Fabricius came with that father of American descriptive entomology, Thomas Say, who in addition to his classic Heteropterous Hemiptera (1832) published, in earlier papers, a great number of descriptions of both Homoptera and Heteroptera. These descriptions, considering the time of their writing (1817-1834), the fact that in many instances no related forms were known for comparison, and no standard set for the group, must be considered as models. While usually short, scarcely ever exceeding a third or half a page in length, they almost invariably succeed in depicting those characters which have specific value and it seldom happens that one is in doubt as to the application of the

description to any particular form. Altogether I figure that Say described 168 species of Heteroptera and 65 of Homoptera, a total of 233 and of these 210 are recognized as good species. A high tribute to his care in examining the European literature for existing descriptions as well as evidence of the virgin field in which he worked.

Two German entomologists, Burmeister (1839) and Germar (1839) in their work on Hemiptera included descriptions of numerous American species and genera and their names appear very frequently in our systematic papers.

Harris contributed in this field not only descriptions of a number of species, but many facts of life history worked out in the admirable manner characteristic of all his work. His studies of 17-year Cicada, Vine Hoppers, Membracids and Chinch Bug have become classics and models for later workers, while many of his specific descriptions are now accepted as covering valid species.

In the work of Amyot and Serville, *Hemipteres*, (1843) there are many references to American species, the greater number perhaps, referring to South American species. A number of North American species also were described by Serville and his connection with our fauna is recognized in the name *Servillei* applied to a species of *Acanalonia*.

Fairmaire's *Revue de la Tribu des Membracides*, published in the *Annales de la Societe Entomologique de France* (1845), includes a number of American species.

Dr. Asa Fitch began his publications on Hemiptera in 1851 and his descriptions, though often inadequate, cover a long list of species and include some of the most important of American insect pests. Aphids, Membracids, Psyllids and Jassids are among the families in which he did his most important systematic work. If we recall that he was a practicing physician, and his entomological work for many years incidental to his vocation, we can appreciate more fully his service to entomology. The descriptions of Membracidae in the *Natural History of New York* (1854) appearing under the name of Emmons, who was a co-worker and whose descriptions are, by some writers, credited to Fitch, must have been with his assistance or collaboration.

The work of Townsend Glover, though including many references to Hemiptera, was not of special value particularly from the taxonomic standpoint.

The List of Specimens of Hemipterous Insects in the British Museum (1851) includes many descriptions of American species by W. S. Dallas.

Walker's descriptions of Hemiptera (1852-1858) like those in other groups, have been a most grievous trial to American students and pilgrimages to the British Museum to see what "Walker's types" are like are perhaps as profitable here as elsewhere. I can testify, however, that in some instances the descriptions (by some credited to another author) are quite satisfactory and fairly represent the species in hand.

To Carolus Stål, a Swedish naturalist of unusual ability, the students of American Hemiptera owe a deep and lasting obligation. His *Hemiptera Mexicana*, *Membraciden*, *Reduviden* and particularly the *Hemiptera Fabriciana* and *Enumeratio Hemipterorum* are among the first desiderata in the Hemipterist's working library. Many of his South American species described in the *Eugenies Resa* and the *Rio Janeiro Hemiptera* occur also in North America and some of them are among our abundant species. Another Swedish entomologist, and a successor to Stål, Spangberg, is to be credited with extensive additions to American Hemipterology, his most important papers being those describing species of *Gypona* and *Jassus* (1878).

Along with other groups a number of Homoptera (1861) were described by Benj. D. Walsh. The loss of his types in the Chicago fire in 1879 was, for Homoptera, somewhat akin to the tragic death of the author. Walsh's concept of genera and his descriptions of Homoptera, while sometimes indefinite, are generally found to be fairly well grounded and available in present taxonomy.

One of the most assiduous students of American Hemiptera was Dr. P. R. Uhler and probably to him more than to any other one man we owe the foundation work for our knowledge of the group. His activity in Hemipterology extended over a long period, from 1859 to 1904, and his bibliography (by Henshaw) of fifty-two titles to which two may be added, indicates his industry and service. A list of his separate papers would in itself constitute a paper and present a considerable history of American literature on the group. We may note especially his "Hemiptera West of the Mississippi River," the "Monographs of Cydnidae and Saldidae," the article "Hemiptera," in the *Standard Natural History*, "Check List of Hemiptera Heteroptera," along with numerous descriptive

papers on species collected in western states and territories by the government surveys and exploring parties. His descriptions are exhaustive and while sometimes apparently too minutely detailed to furnish a quick recognition of species, their application to the details are so accurately stated that, if one has the proper form in hand, he can scarcely have a shadow of doubt as to his determination. His work has covered nearly every family of the order, but his published papers include very little in Aphididae, Psyllidae, Coccidae or Aleurodidae. The families specially indebted to his efforts are Cydnidae, Saldidae, Capsidae, (Miridae) Cicadidae, Fulgoridae, and Jassidae, (Cicadellidae). He was an ardent collector as well as student and hosts of his new species were the result of his own energetic scouring of the localities where he had lived or traveled. The writer can testify to his unselfish aid to students entering this field and he remembers vividly his first visit to the Uhler home in 1882 and the hearty welcome to both the examination of collections and the fireside warmth and hospitality. He was most generous in identifying specimens for others and his service in this direction must be accorded full recognition.

Victor Signoret's contributions to American hemipterology must be given high rank, for while his important memoirs, particularly in the "Tettigonides" (1854-5) and the "Essai sur les Jassidae" (1878) and "Essai sur les Cochenilles" (1869-1874) cover the world, they include so many descriptions of American species and are so necessary in determining genera that they must be at hand for every student of our Hemipterous fauna. Signoret lived in Paris and most of his papers appeared in the "Annals de la Societe Entomologique de France," but his collection, including types of Homoptera, is said to be placed in the museum of the University of Naples, a bit of information that, unfortunately, did not come to me until some years after my winter in Naples, when I would have had time to examine it with care. Of special interest to American students are his papers on Cydnides (1881) and the *Essai sur les Cochenilles* (1869-74) and *Essai sur les Jassides* (1878).

The Abbe Provancher, working in Quebec, Canada, published quite fully on the Hemiptera, and many of our well known species have his name as their authority. His work published in French and mainly in the *Naturaliste Canadienne* (1872) and *Petite Faune de Canada* (1885-90), must be consulted for the recognition of species of the Canadian region.

Thomas' "Monograph of Aphididae" (1879) marked a decided step in the study of this family, for, by bringing together all earlier descriptions and describing many others, it became possible to refer readily to the literature of the group. In later life he devoted his time to Ethnology.

The work by Riley, Pergande and Monell, in this same group (Aphididae), deserves also more than passing notice for dealing particularly with the life histories, they disclosed such an unending series of remarkable habits that many others were inspired to follow in their footsteps. The elucidation of the life history of Phylloxera, of Phorodon and of Aphis gossypi are in themselves sufficient to evidence this point.

Oestlund, Forbes, C. M. Weed and others have added in this family to such an extent that another monograph is now a desideratum. Patch, Baker, Gillette, Palmer, Davis, Wilson, Mason, and others have been carrying forward in this field.

Comstock's work on the Coccidae (1880 and 1883) gave the impulse to American study in this family and his admirable papers have been the main foundation on which later students have built, though we must not forget the magnificent work of Signoret. Pergande also should be credited with work in this group, though little appeared in print under his name.

J. Duncan Putnam's Biological study of Pulvinaria and Aspidiotus ancylus is an example of what this talented naturalist would doubtless have done in this group had not his career been cut short on the threshold of life. Mrs. Fernald's monumental catalogue of Coccidae (1903) must be ranked as one of the outstanding contributions in this field. Cockerell, Marlatt, Sanders, Ferris, MacGillivray and Morrison have been active workers in this family.

W. H. Ashmead, during his earlier years, contributed a number of papers on Hemiptera and was an enthusiastic collector in the group. His name appears as the discoverer of the widely distributed *Peregrinus maidis*, which figures extensively in economic literature.

A. E. Schwartz did considerable work, especially on the Psyllidae, and his extensive collecting added much to the known distribution in other groups.

Otto Heideman, for many years the curator in charge of the collections of Hemiptera in the National Museum, was particularly interested in Lygaeidae, Tingitidae and Aradidae

and published a number of valuable papers in these as well as other groups, mainly in *Proc. Entom. Soc. Washington*.

C. F. Baker, co-author with Gillette of the *Hemiptera of Colorado* (1895), was a remarkable collector and while his later years were devoted to Philippine Hemiptera, his papers on American species cover the period from 1895 to 1906.

Bergroth, the Finnish Hemipterist, whose residence in the United States from 1906 to 1911 gave him an excellent opportunity to study our fauna, contributed many articles especially on the Aradidae and other Heteroptera.

Another famous Finlander, O. M. Reuter, must be credited with a long list of papers dealing with American Hemiptera, perhaps his most important contributions being in the family Miridae, a group which our brilliant young Dr. H. H. Knight had now made his chief study and in which he has added so extensively to our knowledge.

Dr. Geza Horvath, the eminent Director of the Hungarian Museum at Buda Pest, has been responsible for many valuable contributions to American Hemipterology. His discussion of the species common to Europe and America presented at the Zoological Congress at Boston in 1907, and his revisions of American groups have always shown extended study and even when his conclusions are questioned, the illuminating character of his discussions are appreciated.

Dr. A. L. Montandon, of Roumania, during the years 1893 to 1910, contributed a number of papers on the North American Hemiptera, and by exchanges and identifications assisted students in this country in their efforts to build up representative collections of our native species.

Dr. L. Melichar, the Vienna Hemipterist, began his work on American Hemiptera in the nineties and the writer is indebted to him for a number of valuable exchanges as an aid in his comparisons of American and European species or genera. Probably his most important contributions to American Homopterology are found in his very valuable monographs on the different sub-groups of Fulgoridae, notably the Issidae (1906), Dictyophorinae (1912), Acanolininae and Flatinae, and the recent papers on Cicadellinae (1925-27).

For myself, I can claim for this group, only a secondary field of labor, although it has certainly ranked as a major interest from the time I commenced the study of the pine chermes in 1878.

Of a long list of still active workers I shall not speak at length, but I cannot forego mention of the veteran E. P. Van Duzee, whose work for the near half century has done so much to further progress in the studies of this group. His monumental "Catalog of Hemiptera" (1917) is alone a contribution of major worth, but his descriptions and keys in many families are of inestimable value. Other recent workers are J. R. de la Torre Bueno, Parshley, Ball, Sanders, DeLong, Barber, Hungerford, Lawson, Drake, Blatchley and Morrison.

Of later workers not mentioned here, many others have been gathering a wealth of data and gradually working out the details of affinity, life history and ecology which has been the goal that many have sought, but it is evident to all of us that we are only making a start in a field very rich in opportunity. If we can but lay secure foundations on which future workers may build with confidence we shall perhaps have "served our day and generation" and made possible an adequate harmonious structure for the infinite variety of insects included in the group Hemiptera, and which have been at times our hobby, our despair and our ever recurring interest and joy.

BOOK NOTICE.

INSECTS AND CLIMATE. By B. P. UVAROV. Transactions of the Entomological Society of London, Vol. 79 (1931), pp. 1-247, tables I-XXXIX, 53 figures, bibliography and index.

The Editor is breaking all rules in noticing a publication in a Journal but this work is of such importance to all entomologists that it should be brought to the attention of workers in general. It is a very thorough review of the literature on insects and climate and covers the following main subjects (pp. 1-186): Part I. Physical Factors of Insect Life. I. Heat. II. Humidity. III. Other Climatic Factors. IV. Combinations of Several Factors. Part II. Weather, Climate and Insects. V. Relation of Weather to Activities. VI. Daily and Annual Cycles. VII. Climate and Distribution. VIII. Effect of Climate on Abundance. IX. Climate and Weather in Economic Entomology. Bibliography, pp. 187-232, Index to Authors, 233-238, Subject Index, 239-247. This is a summary of the literature similar to Uvarov's previous work, "Insect Nutrition and Metabolism," published in the Transactions, December 31, 1928. It is fully documented and will be the general reference key to the literature up to 1930. Uvarov's two papers are of immense help to entomologists and it is to be hoped that he can continue such work.—C. H. K.

**A REVISION OF THE GENUS STRUMIGENYS OF
AMERICA, NORTH OF MEXICO, BASED ON
A STUDY OF THE WORKERS
(HYMN.: FORMICIDÆ).¹**

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Probably no genus of ants has a more world-wide distribution than the genus *Strumigenys*. In spite of this, paradoxical as it may seem, not only are the habits of the ants little known, but undoubtedly there are many species yet to be described. That the genus is poorly represented in the collections in this country is a fact beyond a doubt.

Due to the small size of the workers of the North American species, their obscure color, their slow method of locomotion, and their habit of feigning death, they are a type of ant that is easily apt to be overlooked by collectors. So far as my knowledge goes, the ants are never found above the surface of the soil, another habit which has made the collecting of them still more difficult. The colonies observed by me have all been small, usually numbering only a few dozen individuals at the most. The largest colony I have seen was one of *Strumigenys louisiana laticephala*, which contained 120 workers, several queens, and many immature forms. The nests of the species of *Strumigenys* are generally found in decaying logs and stumps or in the soil beneath objects lying on the surface.

Usually the colonies are located in the vicinity of the nests of other ants. Whether there is any relationship between the ants, I am unable to say. Some formicologists are inclined to regard the ants as thieves of other ants, with habits similar

¹A contribution from the Mississippi Agricultural Experiment Station.

²ACKNOWLEDGMENTS.—This paper would not have been possible had it not been for the aid and encouragement that I received from many sources. I am especially indebted to Dr. Carl Menozzi, of Chiavari, Italy, who very graciously allowed me the privilege of studying Emery's types. Drs. W. M. Wheeler, W. S. Creighton, W. M. Mann, and W. A. Hilton also kindly furnished me with material, as did the following; Mary Talbot, Helen Green, E. E. Byrd, J. W. Ward, S. W. Simmons, R. M. Graham, G. W. Haug, E. Lott, H. Dietrich, G. L. Bond, and others. To all of these I wish to extend my sincere thanks. The paper would have been far from complete had it not been for Mrs. Sarah Hoke DeBord, who furnished the many illustrations that help to bring out characters too elusive for words. Lastly, I desire to express my sincere gratitude to Professor R. W. Harned, who has as ever very kindly aided and encouraged me in all my studies on ants.

to those of *Solenopsis molesta* Say. It has also been mentioned that the ants, especially those with long mandibles, such as *Str. louisianæ*, might possess the power of leaping forward with them like various species of *Odontomachus*.

Although the generic characters are extremely clear cut as, for instance, the six-segmented antennae, the cordate head, the peculiar type of pilosity, and the usual spongiform processes of both petiole and postpetiole, some of the species at least are not always so distinctive. Like Emery, I have found the head to be the most distinctive part of the body; hence in this paper I have given a large part of the descriptive matter to an enumeration of its characters. In order to bring out additional structures too elusive for words, I have resorted to illustrations.

My excuse for this paper, if there should be one, is that the species of *Strumigenys* are entirely too poorly known in North America. The nine species formerly known for this country were described almost without exception by Emery and Forel. Not only are practically all the types located in foreign countries but also the descriptions of them are in foreign languages in inaccessible magazines. I have been especially fortunate, however, in being able to examine types of the six following species: *Str. rostrata*, *Str. pergandei*, *Str. pulchella*, *Str. ornata*, *Str. clypeata* var. *pilinasis*, *Str. membranifera* subsp. *simillima*. I have not seen types of *Str. clypeata*, *Str. louisianæ*, nor *Str. margaritæ*. Specimens studied by me of the last three species are supposed to be authentic enough, however, for me not to hesitate in basing descriptions on them. I have described the following new forms: *Str. angulata*, *Str. creightoni*, *Str. dietrichi*, *Str. clypeata* var. *laevinasis*, *Str. louisianæ* subsp. *laticephala*, *Str. missouriensis*, and *Str. sculpturata*. Although seven new North American species have thus been added to our fauna and the number of forms in the genus almost doubled, I feel that there are even yet a number of undescribed species.*

*After this article was placed in the hands of the printer, I received several species of *Strumigenys* for identification. None of these were new to science, but since they add a number of distributional records to this paper they are mentioned here.

Strumigenys pergandei Emery was taken by Dr. C. H. Kennedy from an old rotten stump at Shriner's Grove, London, Ohio on September 25, 1931.

Strumigenys pulchella Emery was collected by Miss Mable Schramm from a wet log, in Huron Bog, Willard, Ohio, on August 15, 1931. As well as in a white oak log, 4 miles south of Lowell, Ohio, on September 8, 1931.

The generic description of the *Strumigenys* worker given below has been copied from Emery in *Genera Insectorum*, Fasc. 174C, p. 319 (1922).

"*Worker*.—Not generally varying much in size. Head cordiform, generally longer than wide, not including the mandibles, very noticeably narrowed anteriorly, arc-like emarginate posteriorly, with rounded posterior angles.

Clypeus prolonged over the base of the mandibles, its anterior border curved, rarely straight, occasionally emarginate. Frontal carinae wide, extending above the eye and limiting a scrobe for the base of the antennal scape.

Eye placed under the scrobe.

Mandibles very variable with respect to length, and shape of teeth.

Antennae of 6 segments; first segment of funiculus large, the second and third equal, the two last segments large, especially the last, which is very long; these two segments constitute the club.

Epinotum more or less armed.

Petiole pedunculate, surmounted by a node. Postpetiole rounded or oval. In many species there are at the borders of the node of the petiole and postpetiole, on the ventral surfaces of these segments, even sometimes at the posterior border of the epinotum, some membranous appendages, yellowish and very thin, which, when they are developed, take a spiny aspect."

Wheeler in Bull. Amer. Mus. Nat. Hist., Vol. XLV, p. 668 (1922) divides the genus into two subgenera, namely, *Strumigenys* and *Cephaloxys* F. Smith (= *Trichoscapa* Emery). The keys to the subgenera below are adapted from Wheeler.

KEYS TO SUBGENERA OF STRUMIGENYS.

1. "Mandibles slender, porrect, subparallel; with two or three teeth at the apex; approximate at their base, which is not covered by the short clypeus..... *Strumigenys* sensu strictu.
Mandibles rather short and flattened, narrowly subtriangular; with numerous small teeth along their apical margin; remote at their base, which is covered by the projecting clypeus
Cephaloxys F. Smith (= *Trichoscapa* Emery)".

KEY TO SPECIES OF SUBGENUS STRUMIGENYS.

1. Average size, 2.25 mm.; head not remarkably robust, with rounded occipital lobes; color light ferruginous, with scarcely darker gaster. (Pl. I, Fig. 1)..... *louisianae* Roger.
Average size 2.5 mm.; head rather robust, with posteriorly broad, somewhat angulate occipital lobes; color dark ferruginous with variably infuscated gaster. (Pl. I, Fig. 2)..... *louisianae* *laticephala* subsp. nov.

***Strumigenys* (S.) *louisianæ* Roger.**

Sir. louisianæ Roger, Berlin Ent. Zeitschr. Vol. 7, p. 211 (1863) worker.

Sir. louisianæ Emery, Zool. Jahrb. Syst. Vol. 8, p. 327 (1895).

Sir. unispinulosa Emery, Bull. Soc. Ent. Ital. Vol. 22, p. 67, pl. 7, f. 5 (1890), worker and female.

Worker.—Length: 2.25 mm. (Pl. I, Fig. 1).

Head, excluding mandibles, broad in proportion to its length. Eyes well developed, coarsely faceted. Mandibles somewhat longer than one-half the remainder of the head; masticatory border of each with one small preapical tooth and two large apical teeth, which contain two small teeth between them. Clypeus triangular, much broader than long, with very transverse or truncate anterior border. Antennal scapes moderate, curved but not angulate basally; last segment distinctly longer than the remaining segments of the funiculus. Thorax short, moderately robust; pro-mesonotal suture poorly developed or lacking; meso-epinotal constriction distinct. Epinotal spines about as long as broad, acute apically, directed slightly upward, backward, and outward; each with a very narrow and thin infraspinal lamella. Petiole almost devoid of spongiform processes except for a very narrow area on its posterior border. Postpetiole with a small amount present on its ventral and posterior borders. First gastric segment, in addition to longitudinal striae on the base, reticulately shagreened.

Body reticulate-punctate, subopaque with the following exceptions: mandibles, funiculi, tarsi, and apical portion of gaster.

Head densely, thorax less densely, covered with short depressed, scale-like hairs; petiole, postpetiole, and gaster with longer and more erect clavate hairs.

Ferruginous; appendages lighter, gaster slightly darker.

Strumigenys louisianæ can be readily distinguished from the other species of the genus by the characters here enumerated: (1) its extremely long, slender, sub-cylindrical mandibles, which are peculiarly toothed; (2) its very broad, triangular shaped clypeus, the anterior border of which is decidedly truncate; (3) the large, abundant, scale-like hairs on the head; (4) the almost complete absence of spongiform processes on the petiole and postpetiole; and (5) the reticulate shagreening of the dorsal surface of the first gastric segment.

Type locality: Louisiana (Roger).

Additional localities: Bay Minette River, Baldwin County, Alabama (W. S. Creighton); Sibley, Mississippi (Andrew Fleming).

This species is listed as occurring from Florida westward to Texas and as far south as Costa Rica. Since I have not seen the specimens on which the above records are based, I cannot

be sure whether the specimens in question in many cases were typical *louisianæ* or those of the new subspecies which I am here describing.

This species nests in cavities in rotten logs and stumps or in the soil beneath objects lying on the surface. Mr. Andrew Fleming found winged females present in a nest at Sibley, Mississippi, on July 4. The colony was found in a cavity in an old locust stump.

***Strumigenys* (S.) *louisianæ* *laticephala* subsp. nov.**

Worker.—Length: 2.5 mm. (Pl. I, Fig. 2).

Very similar to *louisianæ* with the following noticeable differences: namely, (1) its larger size; (2) its relatively broader head; and (3) its darker color. General color deep ferruginous brown with infuscated gaster; the color of the latter variable, often approaching black.

Type locality: Longview, Mississippi (M. R. Smith).

Described from 10 workers. Cotypes are in the collection of the Department of Entomology of the Mississippi A. and M. College and my collection.

Other localities: Louisville, Columbus, West Point, Ripley, and Landon, Mississippi (M. R. Smith, J. W. Ward, E. E. Byrd, G. W. Haug, S. W. Simmons); Decatur, Alabama (W. S. Creighton).

This ant is probably commonly distributed throughout the Gulf States. The exact limits of its distribution are uncertain; it may extend much further than is at present known.

Str. louisianæ subsp. *laticephala* is apparently our most common form of *Str. louisianæ* in Mississippi. Nests of these ants are most commonly found in the soil beneath stones, boards, and other objects. One fine colony was found in a crevice in a well rotted log. A nest found in the soil beneath a flower pot at Columbus, Mississippi, on August 4, contained 120 workers, 2 wingless queens, 2 winged queens, and many immature forms. Another colony found at Longview, Mississippi, contained 94 workers, 1 dealate queen, and many immature forms. At West Point, Mississippi, on June 20, a nest was found which contained 77 workers, 5 males, and 1 dealate queen. Males have been taken at the same locality as late as July 10. Frequently the ants are found nesting in very dry soil. On many occasions we have found them nesting in close proximity to colonies of other ants, such as: *Pheidole*

dentata Mayr, *Pheidole vinelandica* Forel, *Solenopsis molesta* Say, *Prenolepis* (*Nylanderia*) sp., *Ponera trigona* var. *opacior* Forel, *Monomorium minimum* Buckley, *Iridomyrmex humilis* Mayr and others.

KEY TO SPECIES OF SUBGENUS CEPHALOXYS FOR IDENTIFICATION OF WORKERS

- 1 Dorsal surface of first gastric segment clearly shagreened, subopaque, infraspinal lamella absent (Pl II, Fig 7) *margaritae* Forel
- Dorsal surface of first gastric segment smooth and shining, infraspinal lamella present 2
- 2 Prothorax not only flattened, but also very strongly marginate laterally, head almost destitute of pilosity except for a pair of short, more or less erect, club-like hairs on the vertex (Pl III, Fig 10), *membranifera* subsp. *simillima* Emery
- Prothorax not as above, head covered more or less abundantly with variable types of pilosity 3
- 3 Clypeus with a few, very long, erect, enlarged hairs, which give it a decorated effect 4
- Clypeus, although bearing different types of pilosity, distinctly not as above 5
- 4 Clypeus broadly rounded anteriorly, erect hairs very much enlarged apically (Pl II, Fig 5) *ornata* Mayr
- Clypeus very acute anteriorly, pilosity not suddenly enlarged apically (Pl II, Fig 6) *dietrichi* sp. nov.
- 5 Mandibles very much elongated, slender, and somewhat subparallel, each with a distinct tooth on its inner margin just in front of the clypeus, which is followed by a long toothless space, before the apical teeth are reached 6
- Mandibles only moderately or not at all elongated, if similar to the mandibles described above, the tooth on their inner margin is hidden beneath the clypeus when the mandibles are closed 7
- 6 Clypeus decidedly truncate anteriorly, thus giving the head a subrectangular appearance, antennal scapes not only short but very strongly angulate basally (Pl I, Fig 3) *angulata* sp. nov.
- Clypeus, although moderately truncate anteriorly, not enough to give a decidedly subrectangular appearance to the head, scapes longer and less angulate basally (Pl I, Fig 4) *pergandei* Emery
- 7 Anterior border of clypeus either truncate or emarginate 12
- Anterior border of clypeus rounded 8
- 8 Sides of the head gradually converging anteriorly 9
- Sides of the head not perceptibly converging anteriorly, more or less subparallel 11
- 9 Clypeus with short, appressed, squamiform or scale-like hairs (Pl III, Fig 9) *clypeata* Roger
- Clypeus with longer, more or less erect hairs 10
10. Dorsal surface of clypeus convex, subopaque (Pl III, Fig 12), *clypeata* var. *pilinosus* Forel
- Dorsal surface of clypeus depressed, surface slightly glabrous (Pl III, Fig 11) *clypeata laevinasis* var. nov.
11. Head relatively robust in proportion to its length, upper half rugulose or tuberculate, mandibles rather robust, convex (Pl IV, Fig 14), *missouriensis* sp. nov.
- Head relatively slender in proportion to its length, surface, although reticulate-punctate not tuberculate, mandibles slender and somewhat laterally compressed (Pl IV, Fig 13) *pulchella* Emery

12. Mandibles somewhat narrowly triangular, flattened dorso-ventrally; each with large, coarse teeth on its entire inner border; clypeus broadly truncate or slightly emarginate. (Pl. II, Fig. 8).....*rostrata* Emery
Mandibles triangular but shorter; each toothed on only a part of its inner surface; clypeus slightly truncate but never emarginate.....13
13. Hairs on head rather abundant, distinctly squamiform. (Pl. IV, Fig. 16),
creightoni sp. nov.
Hairs on head less abundant, longer, and, although slightly enlarged apically, not distinctly squamiform. (Pl. IV, Fig. 15)..*sculpturata* sp. nov.

Strumigenys (C.) *margaritæ* Forel.

Str. margaritæ Forel, Trans. Ent. Soc. London, p. 378 (1893), worker, female, male.

Str. margarita Emery, Bull. Soc. Ent. Ital. Vol. 26, pl. 1, f. 6 (1894), worker.

Worker.—Length: 1.8–2 mm. (Pl. II, Fig. 7).

Head gradually but not strongly converging to the apices of the two closed mandibles. Clypeus broader than long; its anterior border either straight and truncate or else very broadly and feebly rounded; only very slightly narrower anteriorly than posteriorly. Mandibles approximately one-sixth the length of the head alone, each flattened dorso-ventrally, with 12–14 small but rather clearly defined teeth. Eyes large, distinct, coarsely faceted, easily visible from the front when the scapes are not held close to the head. Antennal scapes robust, much narrowed basally but scarcely as angulate as with some of the other species of *Strumigenys*. Thorax short, moderately robust; viewed laterally it forms, except for the interruption in the mesoepinotal region, an almost continuous and moderate arch. Mesoepinotal constriction distinct. Epinotum with two rather prominent, acute, slightly divergent spines, which are directed somewhat upward, backward, and outward; the membranous infra-spinal lamellar process lacking beneath each. Petiole and postpetiole remarkable because of the almost complete absence of the abundant spongiform processes which are so common to other species of *Strumigenys*; with this species the posterior border of the petiole and the ventral and posterior surfaces of the postpetiole alone bear a small amount of aerolar membrane that could scarcely be called spongiform.

Body very abundantly and finely reticulate-punctate, subopaque; mandibles and apical portion of gaster differently sculptured, more glabrous. Dorsal portion of first gastric segment finely shagreened, subopaque; lacking coarse longitudinal striae at the base.

Head and thorax covered with short, curved, weakly developed, scale-like hairs; the hairs on the petiole, postpetiole, and gaster longer, more clavate, suberect.

Ferruginous; gaster scarcely darker.

This is another very distinct species. The characters which distinguish it are as follows: (1) the peculiarly shaped clypeus, which is only very slightly narrower anteriorly than posteriorly, and the anterior border of which is decidedly truncate in appearance; (2) its robust antennal scapes, which are not angulate basally; (3) its large, coarsely faceted eyes;

(4) the absence of membranous infra-spinal lamella beneath each epinotal spine; (5) the almost complete absence of spongiform processes on the petiole and postpetiole; and (6) the peculiar shagreening on the dorsal surface of the first gastric segment as well as the absence of coarse striae at the base.

Type locality: Island of St. Vincent (West Indies).

Other localities: New Braunfels, Texas (W. M. Wheeler); Comal County, Texas (C. F. Baker's collection).

S. margaritæ, which was originally described from an island of the West Indian group, may possibly be distributed throughout the Gulf States, although to date, so far as I am aware, it has been taken only in Texas.

I am not in possession of any data concerning its biology.

***Strumigenys* (C.) *membranifera* subsp. *simillima* Emery.**

Str. membranifera subsp. *simillima* Emery, Bull. Soc. Ent. Ital. Vol. 22, p. 69, pl. 8, f. 5 (1890), worker.

Worker.—Length: 1.5 mm. (Pl. III, Fig. 10).

Head proportionately shorter and more robust than with the other species of *Strumigenys*. Anterior portion of the head distinctly subrectangular due to the peculiar conformation of the clypeus and sides of the head. Clypeus decidedly broader than long, the posterior margin rounded, the anterior border so broadly and very gently rounded as to appear sub-truncate at a superficial glance. Frontal area faintly impressed, only slightly discernible. Mandibles small, sub-triangular, approximately one-fifth the length of the head alone, the superior surface of each distinctly visible. Antennal scapes extremely short and robust, each very strongly angulate basally. Eyes extremely small. Each side of prothorax with a sharp, well developed longitudinal carina, which thus causes the prothorax to be laterally marginate throughout. Meso-epinotal constriction lacking. Spines of epinotum apparently lacking, their absence represented by a very wide, thin, vertical lamella on each side. Petiole and postpetiole with abundant spongiform processes, which are attached to their ventral, lateral, and posterior surfaces and are apparently more lamellar in nature than with the other species of *Strumigenys*.

Head very thickly and coarsely reticulate-punctate, subopaque; dorsal surface of thorax very faintly so, almost glabrous. Mandibles, clypeus, frontal area, pleurae of meso- and metathorax, dorsal surfaces of petiole and postpetiole, and all of gaster smooth and shining.

Pilosity of the body comparatively sparse. Head with a pair of short, erect, club-like hairs on the vertex, and 6-7 somewhat similar hairs on the anterior border of the antennal scapes; remainder of body with the exception of the tibiae, tarsi, and the apex and ventral surface of gaster practically devoid of hairs.

Light to dark ferruginous brown.

This is not only one of the commonest forms of *Strumigenys* in Mississippi, but is also one of the smallest and most easily recognized species. The ant can easily be recognized from other species of *Strumigenys* by (1) the peculiarly subrectangularly shaped anterior portion of the head; (2) its distinctive type of mandibles, the superior surfaces of which are always visible; (3) its very short, robust, angularly bent antennal scapes; (4) its strongly and laterally margined prothorax; (5) the lamellar plates on the epinotum instead of spines; (6) the almost complete absence of scale-like hairs on the body; (7) the presence of two short, erect, club-like hairs on the vertex of the head. My Mississippi specimens have been carefully compared with a cotype from Emery's collection. I have been unable to find any characters by which the two might be distinguished.

Type locality: St. Thomas (Virgin Islands).

Other localities: Avera (H. Dietrich and E. Lott), Waynesboro (G. L. Bond), West Point (M. R. Smith and E. E. Byrd), Belzoni (G. W. Haug), Columbus and Greenwood (J. W. Ward), Mississippi.

Undoubtedly this subspecies occurs throughout the Gulf States certainly as far west as the Mississippi River.

This species has usually been found nesting in the soil beneath various objects which lay on the surface, such as pieces of wood, bricks, stone, concrete, etc. In most instances the soil was rather dry. In one case a colony was found nesting in the woodwork of an old deserted house and in another instance a colony was observed in the bulb of a gladiolus. The largest colony noted probably contained not more than from 75 to 100 individuals. Occasionally the ants are found nesting in close proximity to other ants, but whether there is any association between the *Strumigenys* and the other ants no one has been able to say. We have found *Str. membranifera simillima* nesting near colonies of the following species of ants: *Pheidole dentata* Mayr, *Lasius niger* var. *americana* Emery, *Prenolepis* (*N.*) sp., and *Monomorium minimum* Buckley.

Solitary, wingless queens were collected on a number of occasions. A winged queen was taken at Columbus, Mississippi, on July 18, 1930.

***Strumigenys* (C.) *ornata* Mayr.**

Str. ornata Mayr, Verh. Zool. Bot. Ges. Wien, Vol. 37, p. 571 (1887), worker.

Str. ornata Emery, Bull. Soc. Ent. Ital. Vol. 22, pl. 8, f. 2 (1890); Zool. Jahrb. Syst. Vol. 8, p. 328, pl. 8, f. 20 (1895), worker.

Worker.—Length: 1.6–1.7 mm. (Pl. II, Fig. 5).

Head proportionally slender, gradually converging to a point at the apex of the closed mandibles. Clypeus as long as its greatest width at the base; its sides gradually converging anteriorly and fusing into the rather evenly rounded oval anterior border. Mandibles approximately one-seventh the length of the head alone; teeth lacking on the basal third of each. Antennal scapes moderate, scarcely angulate basally. Thorax with a median pro-mesothoracic carina and a lateral carina on each side of the basal surface of the epinotum, leading to the epinotal spines. Petiole and postpetiole with large spongiform processes, which hide a large part of the petiole and all but the dorsal surface of the postpetiole.

Head, thorax, and petiole reticulate-punctate, subopaque; mandibles, basal portion of clypeus, frontal area, pleurae of thorax, dorsal surface of postpetiole and gaster, smooth and shining.

Clypeus with a pair of exceedingly long, slender, erect hairs and also 8 shorter erect, clavate hairs; remainder of head with a very moderate amount of short, curved, scarcely clavate-like hairs. Hairs on gaster rather sparse, very long and slender, mostly erect, thickest near apex.

Ferruginous brown; gaster varying from deep brown to almost black.

This species can easily be recognized at a glance by the peculiar shape and arrangement of the hairs on the clypeus, which give the head an ornate appearance, hence the name *ornata*. The clypeus with its convergent sides and oval anterior border is also distinctive, although it bears something of a resemblance to the clypeus of *dietrichi*, *clypeata* and its varieties, *pilinasis*, and *laevinasis*. This is one of the smallest species of our *Strumigenys* (1.6–1.7 mm.).

Type locality: Washington, District of Columbia (Theo. Pergande).

Other localities: Louisville, Mississippi (G. W. Haug); Spring Hill, Mobile, Alabama (W. S. Creighton).

This species has been collected so infrequently that its real distribution in North America is inadequately known.

The single worker, which was taken at Louisville, Mississippi, was found on the ground beneath a well rotted pine stump in a moderately dense pine and oak woods. The ground in the vicinity of the stump was covered with a dense layer of leaves. Pergande, who seems to have collected this species more than anyone else, wrote Emery that he had collected the ants amongst

leaves in the vicinity of streams, in cavities in tree trunks, in the earth, and also in the siftings for certain shade and moisture loving beetles. One would infer from the above remarks that *Str. ornata* is strictly a moisture or shade loving type of ant and for that reason is most often associated with the woodland type of ant fauna.

***Strumigenys* (C.) *dietrichi* sp. nov.**

Worker.—Length: 1.7–1.8 mm. (Pl. II, Fig. 6).

Head proportionately long and slender, very strongly converging anteriorly to the apices of the closed mandibles. Mandibles approximately one-sixth the length of the head alone; projecting out prominently in front of the clypeus; each with a prominent acute basal tooth, which is concealed beneath the clypeus when the mandibles are closed. This tooth is followed by a toothless space which occupies scarcely one-half the length of the exposed part of the mandibles, and is in turn followed by the apex of the mandibles that bears 4 or 5 irregular teeth and then a number of subequal denticulae. Clypeus longer than broad, its anterior border forming medianly almost as sharp an apical point or angle as that formed by the posterior border at its insertion between the frontal carinae. Antennal scapes moderate, not angulate basally as with some of the other species; last segment of antennae somewhat longer than the remainder of the funiculi. Thorax with a moderately distinct meso-epinotal constriction. Epinotal spines well developed, acute apically, directed slightly upward, outward, and backward; each with a moderately broad infraspinal lamella beneath. Spongiform appendages of the petiole and postpetiole well developed; present on the ventral surface and posterior border of the petiole and all of the postpetiole except the dorsal surface.

Body reticulate-punctate, subopaque, with the following exceptions: mandibles, pleurae of meso- and metathorax, dorsal surface of postpetiole and gaster, which are smooth and shining. Clypeus and region of frontal area faintly shining due to the finer sculpture. Thorax with a tendency to small longitudinal rugulae, dorsally.

Head covered with moderately abundant and moderately long, curved, scarcely squamiform hairs. Clypeus with 8–10 long, slightly clavate, suberect to erect hairs, which in length and arrangement bear a striking resemblance to those of *Str. ornata*. Petiole, postpetiole, and gaster sparsely covered with long, sub-erect to erect hairs.

Body ferruginous; gaster very dark, almost black; appendages lighter.

This very striking species is easily recognized by the following characters: (1) its long and sharply angulate clypeus, (2) the peculiar arrangement and shape of the hairs which adorn the clypeus, and (3) the unsquamiform or unscale-like hairs which cover the head. *Str. dietrichi* resembles *Str. ornata*, but can be easily distinguished from that species by

the following characters of the workers: (1) the much more acute anterior border of the clypeus, and (2) the distinctly different type of erect hairs on the clypeus.

Type locality: Lucedale, Mississippi, (H. Dietrich).

Described from 7 workers, the cotypes of which are in the collection of the Department of Entomology of the Mississippi A. & M. College and my collection.

Mr. Dietrich, who collected specimens of the ants on different occasions, stated that he found them among the woody frass of logs and stumps while looking for small beetles.

***Strumigenys* (C.) *angulata* sp. nov.**

Worker.—Length: 2–2.5 mm. (Pl. I, Fig. 3).

Head somewhat similar to that of *S. pergandei*, but much more sub-rectangular anteriorly. Eyes variable in size, usually small, and not visible from a frontal aspect of the head. Mandibles approximately three-eighths the length of the head alone; elongate, slender, laterally compressed, converging apically; each mandible with a distinct tooth in front of the anterior border of the clypeus, followed by a very long toothless interval until the apex is reached where there are four prominent teeth followed in turn by five much smaller teeth until the longer, apical tooth is reached. Clypeus almost one and one-half times as broad as long; anterior border transverse, lateral borders converging with the sides of the head in such manner as to give the anterior part of the head a distinctly sub-rectangular effect; both the anterior and lateral borders of the clypeus faintly but distinctly scalloped. Scapes of antennae much more robust than with *Str. pergandei*, each exceedingly angulate basally. Prothorax with a distinct longitudinal carina on each side. Both pro- and mesothorax with a well developed, median carina. Meso-epinotal constriction distinct. Petiole, postpetiole, and gaster not strikingly different from that of *Str. pergandei*.

Body reticulate-punctate, subopaque, with the following exceptions: mandibles, pleurae of most of the thorax, dorsal surface of postpetiole, and all of gaster, smooth and shining.

Pilosity of head similar to that of *Str. pergandei*, but apparently the hairs are not so numerous or perhaps so large. Gaster with similar but more abundant pilosity than that of *Str. pergandei*.

Ferruginous brown; gaster slightly darker.

Str. angulata, as its name signifies, can readily be distinguished from the other species of *Strumigenys* by the very distinct (sub-rectangular) appearance of the anterior part of its head as well as by the very strongly angulate appearance of its antennal scapes. The mandibles bear a close resemblance to those of *Str. pergandei*, but are considerably longer and differently toothed. In addition to the characters just mentioned, the scale-like hairs of the head, although similar to those

of *Str. pergandei*, are noticeably smaller. Although *Str. pergandei* is closely related to *Str. angulata*, one should have little difficulty, however, in separating the two because of the many distinct differences here mentioned. From *Str. membranifera simillima*, which also has a somewhat similarly shaped head and angulate scapes, *Str. angulata* can be distinguished by the mandibles, size, and numerous other characters.

Type locality: Louisville, Mississippi (M. R. Smith).

Described from 14 workers, cotypes of which are in the collection of the Department of Entomology of the Mississippi A. & M. College and my collection.

This very distinctive species was found nesting in a crevice in a rotten log in a rather dense woodland thicket. Since the species has been taken only once in the state, very little is known concerning its biological habits.

***Strumigenys* (C.) *pergandei* Emery.**

Str. pergandei Emery, Zool. Jahrb. Syst. Vol. 8, p. 326, pl. 8, f. 17, 18 (1895), all castes.

Worker.—Length: 2.25–2.5 mm. (Pl. I, Fig. 4).

Head somewhat similar to that of *Str. angulata*, but less rectangular anteriorly. Eyes not visible from a frontal aspect. Mandibles approximately one-fourth the length of the head alone; elongate, slender, laterally compressed, gradually converging apically; each mandible with a prominent robust tooth on its inner margin just in front of the clypeus, this in turn followed by a very long toothless space until the apex of the mandibles is reached where there is a large acute tooth followed by a broadly rounded tooth, and this in turn by a small acute tooth, then a broadly rounded tooth followed by several smaller more or less indistinct teeth. Clypeus with an almost straight, transverse anterior border; lateral borders broadly rounded, gradually converging into the sides of the head without any definite limits. Antennal scapes not only more slender than those of *Str. angulata*, but less angulate basally. Thorax with distinct meso-epinotal constriction; epinotal spines well developed, apically acute and distinct from the thin and narrow infraspinal lamella beneath them. Petiole with spongiform processes on its ventral and posterior surfaces, postpetiole similarly but more abundantly covered except on its dorsal surface.

Body reticulate-punctate, subopaque, with the following exceptions: mandibles, pleurae of the thorax, dorsal surface of postpetiole, and gaster, which are mostly smooth and shining.

Hairs on the head numerous, somewhat similar to those of *Str. angulata*, but larger and more abundant; anterior border of the clypeus with many, usually 14–16 clavate hairs; the anterior margin of the antennal scapes with 8–10 similar hairs. Hairs on the gaster sparse, long, and erect, not enlarged apically.

Color variable, ranging from light to dark ferruginous brown; appendages lighter.

This species can be distinguished by the following characters: (1) its peculiarly shaped mandibles; (2) the distinct type of pilosity of the head; (3) and its large size (2.25–2.5 mm.). *Str. angulata* appears somewhat similar to *Str. pergandei* in the shape of its mandibles, but can readily be distinguished by the different arrangement and shape of the teeth. In addition to this there are other differences, such as the shape of the head, shape of the antennal scapes, etc.

Type locality: Washington, District of Columbia (Theo. Pergande).

Other localities: Maryland and Pennsylvania (Theo. Pergande); Brooklyn, New York (L. F. Barnum, Jr.); Pelee Island, Canada (Mary Talbot); Black Pond, Virginia (W. M. Mann); Oakwood, Illinois (M. R. Smith); Beatty, Pennsylvania (Schmidt); Bronxville, New York (Wheeler); Boston, Massachusetts (Forel).

Str. pergandei appears to be more commonly distributed in the northern and eastern sections of North America, especially in the territory east of the Mississippi River.

The ants have been found nesting in the soil beneath stones and also in the wood of well rotted logs. A log from which a colony was taken by Miss Mary Talbot was so well rotted as to be picked apart easily with one's fingers.

At Urbana, Illinois, a winged female was captured on August 7, while in flight, immediately following a light shower of rain. On August 11, a male was taken in the same locality under similar circumstances.

***Strumigenys* (C.) *clypeata* Roger.**

Str. clypeata Roger, Berl. Ent. Zeitschr. Vol. 7, p. 213 (1863), worker.

Str. clypeata Mayr, Verh. Zool.-Bot. Ges. Wien. Vol. 37, p. 571 (1887), worker; Emery, Bull. Soc. Ent. Ital. Vol. 22, pl. 8, f. 3 (1890), worker; Zool. Jahrb. Syst. Vol. 8, p. 328, pl. 8, f. 21, 22 (1895), worker, female, male.

Worker.—Length: 2 mm. (Pl. III, Fig. 9).

Head, including mandibles, rather slender in proportion to its length. Clypeus scarcely longer than broad, its anterior border evenly and broadly rounded, gradually fusing into the lateral borders without any definite limit. Mandibles approximately one-sixth the length of the head alone; each with a basal tooth (which is hidden beneath the edge of the clypeus when the mandibles are closed) followed by a small, toothless space, and this in turn by the exposed series of more or less irregular teeth. Antennal scapes moderate in size, not angulate

basally. Meso-epinotal suture visible, but the region in that vicinity not strongly constricted as with some of the species. Epinotal spines acute, each with a narrow, thin, infraspinal lamella beneath. Ventral and posterior surface of petiole and practically all but the dorsal surface of the postpetiole with the usual spongiform processes.

Head, thorax, and petiole reticulate-punctate, subopaque. Mandibles, pleurae of meso- and metathorax, dorsal surface of postpetiole, and gaster smooth and shining. On the thorax there is usually a faint median carina running anteriorly-posteriorly.

Clypeus covered with numerous short, appressed, squamiform hairs; remainder of head with rather abundant long, curved, clavate hairs.

Light to dark ferruginous; mandibles, clypeus, and appendages slightly lighter, gaster darker.

Str. clypeata can be distinguished by the following characters: (1) its characteristic clypeus, which is scarcely longer than broad, forms a broadly oval curve; (2) the clypeus is covered by an abundance of short, appressed, squamiform hairs; (3) the remainder of the head contains numerous long, curved, clavate hairs; and (4) the mandibles are flattened dorso-ventrally and bear a row of coarse, irregular teeth on their inner borders. This species, although quite distinctive, has characters which cannot be so easily described as some of the other species of *Strumigenys*. The illustration will bring out these characters far better than a verbal description.

Type locality: Louisiana (Roger).

Other localities: Beatty, Pennsylvania (Schmidt); Carolina (Roger); District of Columbia (Mayr); Lucedale, Mississippi (H. Dietrich).

I have no data on the biological habits of this species.

***Strumigenys* (C.) *clypeata* var. *pilinasis* Forel.**

Str. clypeata var. *pilinasis* Forel, Ann. Soc. Ent. Belg. Vol. 45, p. 339 (1901), worker.

Worker.—Length: 2.2 mm. (Pl. III, Fig. 12).

Very similar to *clypeata*, but differing in the following characters: (1) more convex and also more coarsely toothed mandibles; (2) more slender epinotal spines; (3) somewhat wider infraspinal lamellae; (4) presence of very fine longitudinal rugulae on the dorsal surface of the thorax; (5) generally finer sculpturing; and (6) the very distinct type of pilosity of the clypeus, the surface of which is covered with rather long, curved hairs, which are not squamiform and only little, if at all, enlarged.

This species, which very closely resembles *clypeata*, can be at once distinguished from it by the nature of the pilosity of the clypeus. There are other characters of less importance, such as those mentioned above.

Type locality: Potomac River, near Washington, District of Columbia (Forel).

I do not possess any information on the distribution or the biology of this species.

***Strumigenys* (C.) *clypeata laevinasis* var. nov.**

Worker.—Length: 1.8 mm. (Pl. III, Fig. 11).

This species could be very easily mistaken for *Strumigenys clypeata* var. *pilinasis*. Although closely allied to that species, this new *subspecies* shows the following distinct differences: (1) the size (1.8 mm.) is smaller; (2) the head is relatively more slender in proportion to its length; (3) the clypeus is not only more narrowly oval anteriorly but is also much more depressed dorsally; (4) the mandibles are less convex; (5) the clypeus and frontal area on account of their sculpture are decidedly more shining; (6) the pilosity of the head is sparser, longer, and apparently more slender; and (7) the color is much darker.

The most distinct characteristics of this new subspecies are the shape and sculpturing of its clypeus, which are entirely different from that of any other species of *Strumigenys*.

Type locality: Louisville, Mississippi (M. R. Smith).

Described from three workers, the cotypes of which are in the collection of the Department of Entomology of the Mississippi A. and M. College and my collection.

The workers of this species were collected from a cavity in a well rotted log lying in a ravine in a rather densely wooded area. In this same habitat were collected *Strumigenys louisianae* subsp. *laticephala* and *Strumigenys gunalata*.

***Strumigenys* (C.) *missouriensis* sp. nov.**

Worker.—Length: 1.5–1.8 mm. (Pl. IV, Fig. 14).

Head rather robust, wider in proportion to its length than with many other species of the genus. Mandibles approximately one-sixth the length of the head alone; not flattened dorso-ventrally; only the apical two-thirds toothed, the latter with well defined more or less regular teeth. Clypeus approximately one-fourth broader than long, very broadly rounded throughout, and weakly scalloped. Antennal scapes moderately robust, angulate basally. Last segment of antennal funiculus slightly longer than the remainder of the funiculus. Thorax with pro-mesonotal suture; meso-epinotal suture represented by a definite but not strong constriction. Prothorax and mesothorax bearing a faint median carina. Epinotum with a carina on each side extending from the meso-epinotal constriction to the base of each spine. Epinotal spines more or less fused with the thin but moderately broad infraspinal lamella beneath each. Spongiform processes of about the same abundance and arrangement as with *Str. pulchella*.

Head, thorax, and petiole reticulate-punctate, subopaque; frontal area of head, pleurae of meso- and metathorax, dorsal surface of post-petiole, and gaster, smooth and shining.

Pilosity of body similar to that of *Str. pulchella* with reference to shape, arrangement, and abundance.

Ferruginous brown; gaster darker, appendages lighter.

In many respects the worker of *Str. missouriensis* bears a striking resemblance to the worker of *Str. pulchella*. This is evidenced by their strong similarity in sculpturing, pilosity, spongiform processes of petiole and postpetiole, and so forth. Upon carefully comparing typical workers of the two species the following differences can be noted in the *Str. missouriensis* worker: (1) the head is proportionally broader and more robust; (2) the mandibles are more robust, not so laterally compressed, and therefore more convex; (3) the antennal scapes are more robust and also more angulate basally; (4) the sculpturing of the head is coarser—that is, more rugulose or tuberculate; (5) the pilosity of the clypeus is much less abundant.

Type locality: Columbia, Missouri (Mary Talbot).

Described from six workers, the cotypes of which are in my collection.

Concerning the nesting habit of this species, Miss Talbot wrote me that the ants were found in an *Aphaenogaster fulva* nest under a stone and were rather deep in the nest, which was located in clay soil on a little bluff over a stream. The nest contained not only workers, but also winged females at the date of collection (August 20, 1929).

***Strumigenys* (C.) *pulchella* Emery.**

Str. pulchella Emery, Zool. Jahrb. Syst. Vol. 8, p. 327, pl. 8, f. 19 (1895), worker.

Worker.—Length: 1.5–1.66 mm. (Pl. IV, Fig. 13).

Anterior and lateral borders of clypeus forming a rather broad and more or less regular arc, which somewhat approaches a semicircle; both margins usually more or less scalloped. Mandibles approximately one-sixth the length of the head alone; laterally compressed, apically converging; the masticatory borders occupying about one-half of the visible sections of the mandibles; each with a small but distinct tooth on its inner margin, which is probably hidden beneath the clypeus when the mandibles are closed but is visible when the mandibles are open; following the tooth there is a toothless space until the masticatory border is reached, where there are four rather prominent basal teeth followed by a number of smaller, less distinct teeth. Antennal scapes moderate in size, slightly angulate basally. Thorax not robust; viewed laterally it is slightly arched or carinulate medianly, the carina usually distinct throughout the pro- and mesonotum; meso-epinotal constriction

present; faint lateral carinae extending from the meso-epinotal constriction to the epinotal spines, which are moderate in size and clearly distinct from the infraspinal lamella beneath each. Petiole and postpetiole with well developed spongiform processes, which occur on the ventral and posterior border of the petiole and all of the postpetiole except the dorsal surface. Gaster of the usual shape.

Body reticulate-punctate, subopaque with the following exceptions: mandibles, frontal area, the pleurae of the meso- and metathorax, the dorsal surface of the postpetiole, and the gaster, which are smooth and shining.

Pilosity of the head moderately abundant, short, erect, not strongly enlarged apically; anterior border of clypeus usually with 10-12 forwardly directed hairs; hairs on gaster sparse, long, and erect, not enlarged toward their apex.

Color variable, ranging from light ferruginous brown to deep brown; gaster in some specimens approaching black, in others much lighter colored.

Str. pulchella is one of our smallest and most slender bodied species of *Strumigenys*. The ants can be distinguished from related forms by the following characteristics: (1) the mandibles, which are approximately one-sixth the length of the head alone, are peculiarly shaped; each bears on its inner margin near the base a small tooth, which is partly concealed beneath the edge of the clypeus; this tooth is followed by a small toothless space until the masticatory border is reached where there are four rather prominent teeth followed by a number of smaller, more or less indefinite teeth; (2) the clypeus is very broadly and evenly rounded throughout, forming almost a semicircle, its borders usually distinctly scalloped; (3) the scapes are moderate in size and only faintly elbowed basally; (4) the borders of the clypeus have from 10-12 club-like hairs; and (5) the pro- and mesonotum bear a median longitudinal carina.

Type localities: Washington, District of Columbia, and Beatty, Pennsylvania (Theo. Pergande).

Other localities: Urbana, Illinois (M. R. Smith); Columbus, Aberdeen, West Point, and Lucedale, Mississippi (M. R. Smith, G. W. Haug, J. W. Ward, E. E. Byrd, and H. Dietrich); Frankfort and Philadelphia, Pennsylvania (no collector's name); Mobile and Decatur, Alabama, and Taylorsville, Mississippi (W. S. Creighton); Forest Park, Long Island, New York (L. F. Barnum, Jr.).

Judging from the distributional records, *Str. pulchella* is widely distributed in the states east of the Mississippi River

and very probably farther north and west than this. In Mississippi it is one of the commonest species of the genus.

Colonies are very frequently found in the moist frass beneath well rotted pine stumps and logs. Dr. W. S. Creighton in remarking about the nesting habits of the ants said, "I have always found this ant in very much decayed (red rotten) logs in damp situations." This, however, is not their only type of habitat for in Mississippi we have frequently found colonies in the soil beneath objects, such as bricks, stones, pieces of wood etc., and in many cases the situations could not have been spoken of as especially moist or damp.

We have in a number of instances found colonies of *Str. pulchella* in close proximity to the nests of other ants. Whether there was any relation between the two no one has been able to say. Some of the ants found nesting in the vicinity of this species were: *Tapinoma sessile* Say, *Monomorium minimum* Buckley, *Iridomyrmex humilis* Mayr, *Myrmecina graminicola* subsp. *americana* Emery, *Pheidole dentata* Mayr, and others. The colonies which we have found were never large, usually ranging from a half dozen or so individuals to some fifty or sixty. In some instances specimens may have been overlooked due to their small size, obscure color, habit of death-feigning, etc.

Strumigenys (C.) rostrata Emery.

Str. rostrata Emery, Zool. Jahrb. Syst. Vol. 8, p. 329, pl. 8, f. 23, 24 (1895), worker, female, male.

Worker.—Length: 2-2.5 mm. (Pl. II, Fig. 8).

Head, excluding mandibles, viewed from a frontal aspect, appears truncate because of the straight or very feebly emarginate anterior border of the clypeus. Clypeus broader than long, with moderately converging lateral borders. Mandibles approximately one-fifth the length of the head alone; elongate, but yet somewhat narrowly triangular; flattened dorso-ventrally; each provided throughout the entire length of the inner border with a number of large, coarse teeth. Antennal scapes robust; each slightly angulate basally. Thorax rather short and robust, with a pronounced shoulder-like angle on each side at the point of junction between the pro- and mesothorax. Epinotal spines well developed, acute, about as long as broad at the base and distinct from the infraspinal lamellae. Petiole and postpetiole with the usual conspicuous amount of spongiform processes.

Body reticulate-punctate, subopaque, with the following exceptions: mandibles, frontal area, pleurae of the meso- and metathorax, dorsal surface of postpetiole, and all of gaster except the basally striated area.

Pilosity of the head much sparser and smaller than with *Str. pergandei*. Thorax with an extremely long hair at each humeral angle

and at the angles between the pro- and mesothorax. Pilosity of the gaster sparse, erect, long, not enlarged apically, confined mostly to the venter. Ferruginous brown; first segment of the gaster darker, appendages lighter.

This species can be recognized from most species of *Strumigenys* by its very characteristic mandibles, which are unusually coarsely toothed. Other characters which seem to set it apart from its congeners are: (1) the rather broad truncate clypeus; (2) the long single hair at the humeral angles of the thorax and at the angles made by the pro- and mesothoracic segments; and (3) the robust, somewhat angulate antennal scapes.

Type locality: Washington, District of Columbia (Theo. Pergande).

Other localities: Virginia, near Plummerville, Maryland (W. M. Mann); Angelsea, New Jersey (determined by Pergande); Claremont, California (C. F. Baker); Baldwin County, Alabama (W. S. Creighton).

The distributional records show that *Strumigenys rostrata* is distributed as far north as New Jersey and westward to California.

Unfortunately I possess little information on the biology of this species. Dr. W. S. Creighton, who took a single worker of this species in Baldwin County, Alabama, informed me that the specimen was obtained on the bark of a decaying stump.

***Strumigenys* (C.) *creightoni* sp. nov.**

Worker.—Length: 1.9–2.1 mm. (Pl. IV, Fig. 16).

Head resembling that of *Str. pulchella*, but proportionally narrower anteriorly. Anterior border of clypeus straight or very faintly rounded, thus giving the clypeus a much more decidedly truncate appearance than with *Str. pulchella*. Mandibles not only more robust but also more flattened dorso-ventrally and without the strongly reflexed apical masticatory border of *Str. pulchella*. The longitudinal carina of the pro- and mesothorax very poorly developed, those of the epinotum very weak or missing. Sculpturing similar to that of *Str. pulchella* but much coarser, thus giving the body a more granulated appearance. Pilosity of head rather abundant, short, similar to that of *Str. pergandei*, but apparently not quite so large. Border of clypeus with 14–16 anteriorly directed scale-like hairs.

Ferruginous; mandibles, antennae, and legs lighter.

This species, although bearing considerable resemblance to *Str. pulchella*, shows its distinctiveness in the following characters: (1) its more flattened and differently shaped mandibles; (2) its proportionally narrower head anteriorly; (3) its more

truncated clypeus; (4) the more abundant and spatulate shaped hairs of the head; (5) the absence of, or weak development of, the lateral carinae of the thorax; and (6) its larger size (2.1 mm.).

Type locality: Spring Hill, Mobile, Alabama (W. S. Creighton).

Described from four workers, the cotypes of which are in my collection.

***Strumigenys* (C.) *sculpturata* sp. nov.**

Worker.—Length: 1.75–1.8 mm. (Pl. IV, Fig. 15).

Very closely allied to *Str. pulchella*, but distinct from this species in the following characters: namely, (1) its more robust head, the width of which is greater in proportion to its length; (2) the more rugulose or tuberculate sculpturing of its head; (3) its more robust and coarser type of mandibles; and (4) the decidedly truncate shape of the anterior border of its clypeus. From *Str. missouriensis*, to which it also bears a striking resemblance, it can be at once separated by the shape of its clypeus, as well as by the slightly less robust mandibles.

Type locality: Aberdeen, Mississippi (M. R. Smith).

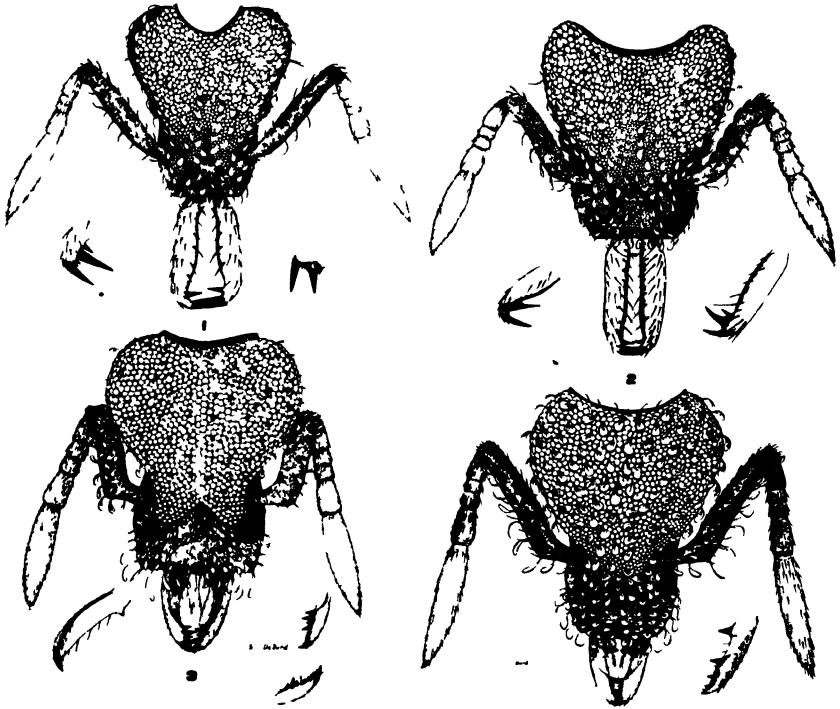
Described from seven workers, the cotypes of which are in the collection of the Department of Entomology of the Mississippi A. & M. College and my collection.

To this species I have also referred specimens from Ripley, Mississippi (S. W. Simmons) and Black Pond, Fairfax County, Virginia (W. M. Mann).

This species nests beneath the bark of rotten logs and stumps as well as in the soil beneath objects lying on the surface.

BIBLIOGRAPHY.

- Emery, C.** Bull. Soc. Ent. Ital. Vol. 22, p. 67, pl. 7, f. 5 (1890), worker and queen (*Str. unispinulosa*).
 ibidem, Vol. 22, p. 69, pl. 8, f. 5, (1890), worker (*Str. membranifera* subsp. *simillima*).
 ibidem, Vol. 22, pl. 8, f. 2 (1890), (*Str. ornata*).
 ibidem, Vol. 22, pl. 8, f. 3 (1890), worker (*Str. clypeata*).
 ibidem, Vol. 26, pl. 1, f. 6 (1894), worker (*Str. margaritæ*).
 Gen. Insect. Fas. 174 C, pp. 319–325 (all species of *Strumigenys*).
 Zool. Jahrb. Syst. Vol. 8, p. 326, pl. 8, f. 17, 18 (1895), all castes (*Str. pergandei*).
 ibidem, Vol. 8, p. 327, pl. 8, f. 19 (1895), worker (*Str. pulchella*).
 ibidem, Vol. 8, p. 327 (1895), (*Str. louisianæ*).
 ibidem, Vol. 8, p. 328, pl. 8, f. 20 (1895), worker (*Str. ornata*).
 ibidem, Vol. 8, p. 328, pl. 8, f. 21, 22 (1895), all castes (*Str. clypeata*).
 ibidem, Vol. 8, p. 329, pl. 8, f. 23, 24 (1895), worker (*Str. rostrata*).
Forel, A. Trans. Ent. Soc. Lond., p. 378 (1893), all castes (*Str. margaritæ*).
 Ann. Soc. Ent. Belg. Vol. 45, p. 339 (1901), worker (*Str. clypeata* var. *palinasis*).
Mayr, G. Verh. Zool.-bot. Ges. Wien, Vol. 37, p. 571 (1887), worker (*Str. clypeata*).
 ibidem, Vol. 37, p. 571 (1887), worker (*Str. ornata*).
Roger. Berlin Ent. Zeitschr. Vol. 7, p. 211 (1863), worker (*Str. louisianæ*).
 ibidem, Vol. 7, p. 213 (1863), worker (*Str. clypeata*).
Wheeler, W. M. Bull. Amer. Mus. Nat. Hist. Vol. 45, p. 668 (1922), (Keys to American species of *Strumigenys*).



- Fig. 1 Frontal view of head, and mandibles of *Str louisiana* Roger
Fig. 2 Frontal view of head, and mandibles of *Str louisiana laticephala* subsp nov.
Fig. 3. Frontal view of head, and mandibles of *Str angulata* sp nov
Fig. 4. Frontal view of head, and mandible of *Str pergandei* Emery

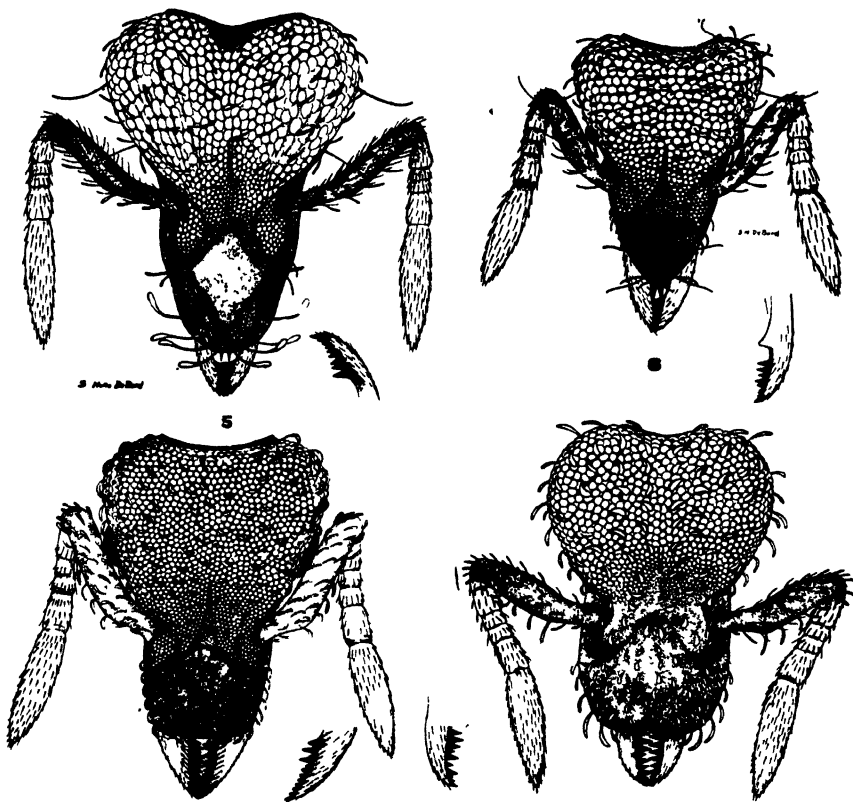


Fig. 5. Frontal view of head, and mandible of *Str. ornata* Mayr.

Fig. 6. Frontal view of head, and mandible of *Str. dietrichi* sp. nov.

Fig. 7. Frontal view of head, and mandible of *Str. margarita* Forel.

Fig. 8. Frontal view of head, and mandible of *Str. rostrata* Emery.

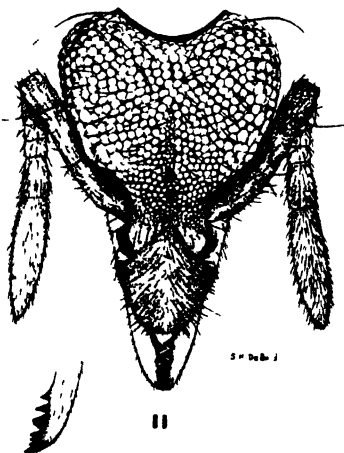
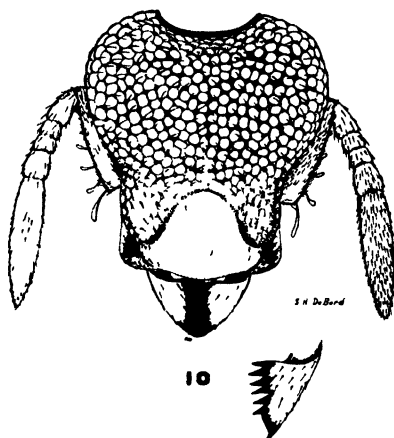
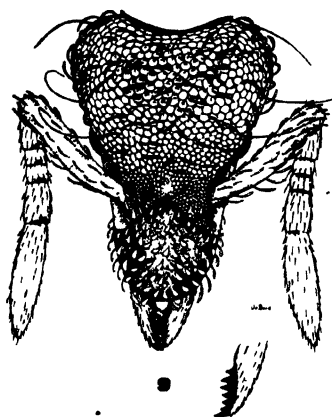


Fig. 9. Frontal view of head, and mandible of *Str. clypeata* Roger.

Fig. 10. Frontal view of head, and mandible of *Str. membranifera* subsp. *simillima* Emery.

Fig. 11. Frontal view of head, and mandible of *Str. clypeata* var. *laevinasis* var. nov.

Fig. 12. Frontal view of head, and mandible of *Str. clypeata* var. *pilinasis* Forel.



Fig. 13. Frontal view of head, and mandible of *Str. pulchella* Emery.
Fig. 14. Frontal view of head, and mandible of *Str. missouriensis* sp. nov.
Fig. 15. Frontal view of head, and mandible of *Str. sculpturata* sp. nov.
Fig. 16. Frontal view of head, and mandible of *Str. creightoni* sp. nov.

A PRELIMINARY REVISION OF THE AMBUSH BUGS OF NORTH AMERICA, (HEMIPTERA, PHYMATIDÆ).*

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Oshkosh High School, Oshkosh, Wis.

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INTRODUCTION.

The present paper is the result of a study of as many North American species of this family as could be obtained. Approximately three thousand five hundred specimens were examined, and several undescribed species were encountered in both of the genera found in this region, namely, *Phymata* and *Macrocephalus*. Most of the work on the North American forms has been done by Europeans, especially Handlirsch and Melin. These authors, however, studied relatively few specimens so that several species remained undescribed. These have been lumped under the old names by American workers, as has been shown by the names applied to specimens received for study. Further study of forms that appear new but are represented by too few specimens to warrant hasty conclusions, is necessary before a complete revision is published. The writer hopes to complete such a revision in the near future, and will be very glad to receive material for determination from North and Central America.

ACKNOWLEDGMENTS.

The writer wishes to express his acknowledgments to those who in some special way have given aid in the preparation of this paper. He is especially indebted to Dr. Max Beier, of the K. K. Naturhistorischen Hofmuseums, Vienna, who was

*Contributions from the Entomological Laboratories of the University of Illinois, No. 153.

kind enough to send specimens named by Handlirsch for use in this study.*

In addition the writer is particularly indebted to the following persons for much valuable aid in preparing the paper: Professor C. L. Metcalf; Dorothy Ann Evans; Herbert H. Ross, who gave valuable aid in many ways; and Carl O. Mohr, who prepared figures 1A and 1B.

TAXONOMY AND NOMENCLATURE.

Males may be distinguished by the elongate, rounding, external covering of the genitalia, females by the flap-like, sub-triangular covering.

FAMILY PHYMATIDÆ.

KEY TO THE NORTH AMERICAN GENERA.

Scutellum short and triangular; a small degenerate tarsus present on the forelegs.....Genus **Phymata** Latr.
Scutellum elongate, covering the wings; no tarsus on the forelegs, Genus **Macrocephalus** Swed.

Genus **Phymata** Latrielle.

KEY TO THE SPECIES.

1. Small species, 5-6.5 mm.; colors other than black and yellow or black and green. 2
Larger species, 6-11.5 mm.; colors of varying combinations, or almost uniformly one. 3

*Others who loaned material and to whom the writer is deeply indebted are the following: W. J. Baerg, of the University of Arkansas; E. D. Ball, of the University of Arizona; H. G. Barber, Washington, D. C.; S. W. Bilsing, of the A. and M. College, Texas; C. S. Brimley, North Carolina Department of Agriculture; J. Chester Bradley, of Cornell University; Lawson Caesar and R. H. Osburn, of the Ontario Agricultural College, Guelph, Canada; T. D. A. Cockerell, of the University of Colorado; Dr. Alfons Dampf, of the Mexican Department of Agriculture; J. J. Davis, of Purdue University; G. A. Dean and Roger C. Smith, of Kansas State Agricultural College; R. W. Doane, of Stanford University; C. J. Drake, of the Iowa State College; E. O. Essig, of the University of California; T. H. Frison, of the Illinois State Natural History Survey, Urbana; C. P. Gillette and S. C. McCampbell, of the Colorado Agricultural Experiment Station; R. D. Glasgow and K. F. Chamberlin, of the New York State Museum; T. L. Guyton, Bureau of Plant Industry, Harrisburg, Pennsylvania; R. W. Harned and S. W. Simmons, of the Mississippi A. and M. College; T. J. Headlee, New Jersey Agricultural Experiment Station; W. E. Hinds, of the Louisiana State University; the late J. S. Hine, of the Ohio State Museum; H. B. Hungerford, of the University of Kansas; Carl T. Schmidt, of the University of Minnesota; D. C. Mote, of the Oregon Agricultural College; P. R. Lowry, of New Hampshire Agricultural Experiment Station; H. Osborn, of Ohio State University; H. M. Parshley, Northampton, Massachusetts; H. C. Severin, South Dakota Agricultural Experiment Station; M. H. Swenk, University of Nebraska; R. S. Usinger, Oakland, California; E. P. VanDuzee, California Academy of Sciences; Harold Morrison, H. G. Barber, and J. E. Graf, of the U. S. National Museum.

2. Abdomen rather broadly rounding; points of connexiva projecting prominently; pronotum roughly finished; membrane of wings with no small round cells at the apex; Figs 13 and 14. *vicina* Handl.
Abdomen slender and tapering; points of connexiva blunt and barely projecting; pronotum almost smooth; membrane of wings with small round cells near the apex; Figs 11 and 12. *luxa* n. sp.
3. With spine-like projections on the pronotum, sides of thorax, fore-femora, and elsewhere. 4
With smooth granules of varying size and in varying numbers on the above named regions. 5
4. Fore-femora with granules and only a few fine spines; sides of thorax with granules rather than spines; anterior half of pronotum with short spines; lateral notch about as deep as wide, (Figs 25 and 26); occurs in Mexico. *granulosa* Handl.
Fore-femora thickly covered with prominent elongate granules bearing spines; sides of thorax the same; pronotum with spines scattered on posterior half as well as the anterior; lateral notch wider than deep, (Figs 27 and 28); occurs in Arizona. *rossi* n. sp.
5. Membrane of wings with many rounding cells, and with the veins interwinding. 6
Membrane of wings with no round cells and the veins not interwinding. 7
6. Frontal processes sharply upturned and pointed; lateral edges of pronotum rather thin and upturned; no distinct lateral notch, (Fig. 10); fourth connexivum ending in one point. *albopicta* Handl.
Frontal processes rather blunt and slightly upturned; lateral edges of pronotum thick and not upturned; a distinct lateral notch, (Fig. 16); fourth connexivum three lobed, the middle one longest. *noualhieri* Handl.
7. Pronotum, as seen from the top and also from the side, with a shallow lateral notch which appears as a slight sinuation of the edge, (Figs. 29 and 30); posterior lobe of pronotum not much raised or widened; occurs in Arizona, Colorado, Idaho, and Utah. *borica* n. sp.
Pronotum with a distinct lateral notch as seen from the top and side. 8
8. Species entirely deep red in color; sharp lateral process to the posterior lobe of pronotum, (Fig. 15); occurs in California. *arctostaphylæ* Van D.
Species other than red in color. 9
9. Posterior lobe of pronotum widely flaring and greatly upturned with long lateral point; lateral notch deep, (Figs. 17, 18, 19 and 20). 10
Posterior lobe of pronotum moderately flaring and upturned, or not; lateral notch moderate, (Figs. 2, 3, 4, 5, 6, 7, 8, examples). 11
10. Lateral process sharply pointed and elongate; deep lateral notch, (Figs. 17 and 18); tips of connexiva only slightly projecting; occurs in Mexico, *fasciata* (Gray)
Lateral process less sharply pointed and shorter; lateral notch not as deep, (Figs. 19 and 20); tips of connexiva more projecting; widely distributed, (see text); another form of this with more rounding posterior lobe keys down later. *fasciata georgiensis* Melin
11. Lateral process and posterior corner of pronotum very sharply pointed, (Figs. 23 and 24); abdomen flaring quite abruptly to the widest point; occurs in Florida, Georgia. *mystica* n. sp.
Lateral process and posterior corner of pronotum moderately pointed or rounding; abdomen not flaring abruptly to the widest point. 12
12. Connexiva projecting in prominent, small tips; posterior lobe of pronotum, as seen from above, and from the side, rounding or with a blunt tip, (Figs. 21 and 22); longitudinal ridges with distinct knobs towards the anterior part; widely distributed. *fasciata georgiensis* Melin
Connexiva, if projecting, only forming a simple angle. 13
13. Ocellar processes slender and noticeably long as seen from above, not much thicker at the base. 14
Ocellar processes short, and not strikingly noticeable as seen from above, arise from a thickened base. 16

14. Terminal antennal segment of the male always longer than the preceding two united, the average one and one-third times as long; in the female the apical antennal segment is about 0.9 as long as the preceding two united; points of connexiva hardly projecting; first three connexiva rarely with a dark spot at the base; East of the Mississippi River; (Figs. 2 and 3)..... **pennsylvanica** Handl.
Terminal antennal segment of the male never one and one-third times as long as the preceding two united, rarely as long as the two united, in the female much shorter; ocellar processes more developed and noticeable.... 15
15. Ocellar processes slender and twig-like; longitudinal ridges of pronotum hardly widening at the anterior part; pronotum from the lateral aspect as in Figs. 4 and 5; our most common form, (see distribution),
pennsylvanica americana Melin
Ocellar processes stouter and less twig-like; longitudinal ridges of pronotum noticeably widening at the anterior part; pronotum from lateral aspect as in Figs. 6, 7, 8 and 9; a western form, (see distribution),
pennsylvanica coloradensis Melin
16. Posterior corner of pronotum very blunt, or rounded as seen from above; lateral process of pronotum bluntly pointed, or rounded, (Figs. 31, 32, 35 and 36)..... 17
Posterior corner of pronotum distinctly and sharply pointed; lateral process of pronotum distinctly pointed, (Figs. 33, 34, 37, 38, 39 and 40).... 18
17. Frontal processes noticeably tapering anteriorly; connexiva hardly projecting and only in blunt angles; occurs in Arizona and California; (Figs. 31 and 32)..... **salicis** Ckll.
Frontal process not tapering noticeably anteriorly; connexiva projecting in distinct small points; occurs in Mexico; (Figs. 35 and 36). **severini** Handl.
18. Membrane of wings hyaline;* color green with black markings, in older specimens the green turning into a very light buff; occurring in Oregon and British Columbia; (Figs. 33 and 34)..... **metcalfi** n. sp.
- Membrane of wings brown*..... 19
19. Connexiva and ventral surface of abdomen with very few, if any, small granules; fore-femora with very few, if any, small granules on the outer surface; occurring in California; (Figs. 37 and 38).... **pacifica** n. sp.
Connexiva and ventral surface of abdomen with a varying number of distinct small granules; fore-femora rather thickly covered with granules on the outer surface; occurs in California; (Figs. 39 and 40),
pacifica stanfordi n. sp.

Phymata pennsylvanica Handlirsch.

(Figs. 2 and 3.)

Phymata erosa pennsylvanica Handlirsch, Ann. K. K. Nat. Hofm., Wien, XII, 1897, p. 163.

Phymata americana newyorkensis Melin, Arkiv for Zoologi, Band 22A, No. 2, October 8, 1930, p. 7.

This species was considered under the name *newyorkensis* by Melin who discredits Handlirsch's name *pennsylvanica* on the basis of insufficient description. According to the International Rules of Nomenclature Handlirsch's description and figure are sufficient to make his name valid. The removal of this and related forms from a subspecific position in relation to *erosa* and the demonstration by Melin that *fasciata* also

*Membrane of wings is not transparent and the color seen is that of the membrane itself and not that of the abdomen showing through it.

belongs to a species distinct from *pennsylvanica*, leaves this latter name the prior available name for the species complex to which it belongs. Melin erected the name *americana* to accommodate this species complex but *pennsylvanica* has thirty-three years priority over his name.

This subspecies may be identified from the allied ones by the long apical antennal segment. The ratio of this segment to the preceding two united, averages 1.3:1 in the male. Extremes, in a series measured, average 1.14:1 to 1.42:1 in the male. In the female this segment is noticeably longer and more slender than those of the allied subspecies. It averages 0.9:1. The abdomen is more slender than in *Phymata pennsylvanica americana* and the connexiva form an almost perfectly smooth line. Fourth connexivum is narrower, and more acutely angled than in the above named subspecies. No basal dark spots on connexiva. The specimens examined, totalling about 300, came from the following states: New York, Pennsylvania, District of Columbia, West Virginia, Ohio, Massachusetts, North Carolina, Kentucky, Georgia, Indiana, New Jersey, and Connecticut.

***Phymata pennsylvanica americana* Melin.**

(Figs. 4 and 5.)

Phymata erosa fasciata auctt. (See VanDuzee, 1917).

Phymata americana wisconsinia Melin, Arkiv for Zoologi, Band 22A, No. 2, October 8, 1930. p. 6.

Phymata americana ottawensis Melin, *Ibid.*, p. 7.

Melin proposed the name *americana* to include a complex of four subspecies which he called *wisconsinia*, *coloradensis*, *ottawensis* and *newyorkensis*. According to Article 52 of the Entomological Code, one of the subspecific names should be a repetition of the species name. One of Melin's subspecific names should therefore be changed to *americana*. Since *wisconsinia* is the first subspecies described, it is taken as the typical form and *americana americana* substituted for *americana wisconsinia*. Handlirsch's name *pennsylvanica*, however, applies to one of the subspecies of this group, and, since it is the prior name, supplants *americana* as the specific name of the complex. The subspecies *ottawensis* of Melin is included in this one, because the name is based only on a few individual variants.

This subspecies is characterized by the long twig-like ocellar processes in both sexes. Connexiva project in blunt points, and usually bear a small dark basal mark.

Specimens were examined from the following states: Massachusetts, New York, District of Columbia, Virginia, Delaware, New Jersey, Maryland, North Carolina, Pennsylvania, Ohio, Indiana, Illinois, Wisconsin, Michigan, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Kansas, Nebraska, Arkansas, Colorado, and Montana. The total number of specimens examined was in excess of 1200.

***Phymata pennsylvanica coloradensis* Melin.**

(Figs. 6, 7, 8 and 9.)

Phymata americana coloradensis Melin, Arkiv for Zoologi, Band 22A, No. 2, October 8, 1930, p. 7.

This form differs from *pennsylvanica americana* in the following ways. Shape of the pronotum is wider, more flaring (in the typical form, Figs. 6 and 7). Ocellar processes thicker and less twig-like. Longitudinal ridges more distended anteriorly. General size larger.

There is considerable variation in the shape of the pronotum, but a graded series can be made showing the relationship. The two extremes in pronotal shape are illustrated (Figs. 6, 7, 8, 9).

The states represented in the collection were Kansas, Nebraska, Arizona, Colorado, New Mexico, Oregon, Utah, and Washington. 250 specimens were examined.

***Phymata fasciata* (Gray).**

(Figs. 17 and 18.)

Syrts erosa fasciata Gray, Griffith's Anim. Kingd., XV, 1832, p. 242.

Phymata fasciata mexicana Melin, Arkiv for Zoologi, Band 22A, No. 2, October 8, 1930, p. 10.

Melin has demonstrated in his recent work that *P. erosa* is a distinct type and limited to Surinam and the nearby territory. He then proposes that *fasciata* Gray become a species complex, and names two subspecies under it, *fasciata georgiensis* and *fasciata mexicana*. According to Article 52 of the Entomological Code, one of the subspecific names should be a repetition of the species name. One of Melin's subspecific names should therefore be changed to *fasciata*. It so happens that the specimens examined from the K. K. Naturhistorischen Hofmuseums, Vienna, and bearing Handlirsch's determination are the subspecies called *mexicana* by Melin. Hence the name *fasciata* is the prior name for this subspecies.

This subspecies is characterized by the flaring pronotum with a sharp, pointed, lateral process, the deep lateral notch (Figs. 17 and 18), the wide, spreading abdomen, and the distribution, which is restricted to Mexico. Eleven specimens were examined, all from Mexico.

***Phymata fasciata georgiensis* Melin.**

(Figs. 19, 20, 21 and 22.)

Phymata erosa fasciata auctt. (See VanDuzee, 1917).

Phymata fasciata georgiensis Melin, Arkiv for Zoologi, Band 22A, No. 2, October 8, 1930, p. 9.

This subspecies may be differentiated from *fasciata* Gray by the pronotum, which is not as flaring, and which has a blunt lateral process, or one which is rounding (Figs. 19, 20, 21 and 23). The lateral notch is slightly smaller, and the abdomen is narrower throughout. This subspecies is quite variable, and certain forms may eventually be separated into another subspecies, but further study is desirable before such a step is taken.

The distribution of this subspecies is quite surprising. Specimens studied came from the following states: District of Columbia, New Jersey, Maryland, Virginia, North Carolina, Georgia, Florida, Louisiana, Mississippi, Ohio, Illinois, Missouri, Nebraska, Kansas, Arkansas, Oklahoma, Texas, and New Mexico. About 385 specimens were examined.

***Phymata mystica* new species.**

(Figs. 23 and 24.)

MALE:

Size and General Color.—Length of body, 7.5 to 8.5 mm. Width of pronotum, 3 to 3.6 mm. Ground color black or dark brown with a contrasting yellow or buff. Head either entirely black with buff colored antennae, or entirely buff colored, or buff with a black basal region. Pronotum either black or varying shades of brown, with the lighter colors at the anterior corners and a light margin along the lateral notch. Sides of thorax either entirely black or brown, or with a combination of these colors. Legs greenish yellow to buff, with no markings. The forelegs may sometimes be darker than the second and third pairs. Scutellum similar to the pronotum. Corium dark or a lighter shade of brown with a cross band of lighter color. Membrane brown. Abdomen entirely yellow or buff except for a black or dark brown transverse band on the fourth and basal half of the fifth segments, and a corresponding mark at the apex, which may extend completely across the tip, or be only a spot on either side.

Head and Antennae.—Frontal processes extending slightly beyond the first antennal segment, and usually rather sharply pointed. Dorsally the head narrows slightly toward the tip. Ocellar processes short

and blunt. Preocellar processes indistinct. Surface of head studded with small smooth granules. Antennae with the terminal segment almost as long as the preceding two united. The ratio is 0.9 to 1.

Thorax and Appendages.—Pronotum with almost no granulation but roughened. Anterior lobe slightly rounding. Lateral notch rather deep and narrow. Posterior lobe greatly raised and with two very sharp and distinct points (Figs. 23 and 24). Longitudinal ridges slightly raised, narrow, and with a distinct raised knob at the anterior at the highest point. Sides of thorax with very few granules, those present being mainly along the edges and at the antennal groove. Legs rather strikingly smooth. Corium without any granules. Scutellum with a vein and a distinct median ridge.

Abdomen strikingly widened with the corners of the first three connexiva sharply projecting, and the fourth acutely angled and much wider. Fifth connexivum almost as wide as the fourth. Fifth and sixth segments forming a rather wide and short apex to the abdomen. Abdomen almost devoid of granules, those found being inconspicuous and scattered.

FEMALE:

Length, 8.5 to 10 mm. Width of pronotum, 3.5 to 4.2 mm. Color as in the male but lighter. Terminal antennal segment about three-fourths as long as the preceding two united. Otherwise as in the male.

Holotype.—♂, Dunedin, Florida, April 12, 1915 (W. S. Blatchley). Deposited in the collection of the Illinois State Natural History Survey, Urbana.

Allotype.—♀, Leesburg, Florida, Sept. 10, 1930 (C. Goff). Deposited with the holotype.

Paratypes.—5 ♂♂, 5 ♀♀, Dunedin, Florida, Oct. 23–30, 1914 (Blatchley); 3 ♂♂, 3 ♀♀, Jacksonville, Florida; 5 ♂♂, 1 ♀, Florida; 1 ♂, 1 ♀, Billy's Island, Okefenokee Swamp, Georgia, June, 1912; 1 ♂, 2 ♀♀, Gainesville, Florida, July 7–28, 1918 (C. J. Drake); 2 ♀♀, Tampa, Florida, Fall 1927 (C. O. Bare); 2 ♂♂, Ft. Myers, Florida, April 1, 1922 (J. N. Knull) and March 31, 1912 (H. G. Barber); 1 ♂, Cleveland, Florida, April, 1925 (J. N. Knull); 1 ♀, same locality, April, 1927 (D. M. DeLong); 1 ♂, 2 ♀♀, Leesburg, Florida, Sept. 10, 1930 (C. Goff); 1 ♂, Punta Gorda, Florida, Nov. 13, 1911 (Wm. T. Davis), 1 ♀, Waynesville, Georgia, Sept. 10, 1909; 1 ♀, St. Augustine, Florida (C. T. Brues); 1 ♂, Miami, Florida (J. C. Hamlin); 1 ♀, Orlando, Florida, April, 1929 (D. M. DeLong); 2 ♂♂, Miami, Florida, Nov. 3, 1912; 2 ♂♂, Orlando, Florida, May 21, 1922 (H. E. Ewing) and Aug. 23, 1907 (Russell). Distributed in the collections of Cornell University; Purdue University; Agricultural Experiment Station, Fort Collins,

Colorado; H. M. Parshley; Bureau of Plant Industry, Harrisburg, Pennsylvania; H. G. Barber; Iowa State College; University of California; University of Kansas; Agricultural Experiment Station, Tucson, Arizona; U. S. National Museum; and the author.

This species is allied to *P. fasciata georgiensis* Melin and can be separated from it by the following characters. Abdomen flaring more abruptly to the widest point, and more rounding to the apex. Projecting tips of connexiva shorter and not as sharply pointed. Posterior lobe with a sharp pointed lateral process and posterior corner. A short deep curve leading from the lateral process to posterior corner. Longitudinal ridges narrower and with a smaller knob at the anterior end. Colors black and yellow rather than a reddish brown and yellow as found in *georgiensis*.

This species has been named *P. guerini* by previous American authors, but is not the *guerini* of Handlirsch. Specimens of the true *guerini* named by Handlirsch and coming from the typic locality, Cuba, differ very markedly from *mystica*.

Phymata arctostaphylæ VanDuzee.

(Fig. 15.)

Phymata erosa arctostaphylæ VanDuzee, Trans. San Diego Soc. Nat. Hist., 2, 1914, p. 11.

This species is being raised from a subspecies of *erosa*, because of Melin's discussion of that form. It appears as a distinct species being distinguished by the upright posterior pronotal lobes with sharp, long, lateral processes, the sharp, posterior corner, very small lateral notch, and the thin, rather sharply raised, longitudinal ridges (Fig. 15). The sharply projecting and acutely angled fourth connexiva are similar to *P. mystica*, which is probably the most closely allied species but it can be distinguished by the above characters and the striking red color which VanDuzee states is diagnostic.

One specimen from California sent to me by Professor E. P. VanDuzee.

Phymata granulosa Handlirsch.

(Figs. 25 and 26.)

Phymata erosa granulosa Handlirsch, Ann. K. K. Hofm., Wien, XII, 1897, p. 163.

Phymata granulosa Melin, Arkiv for Zoologi, Band 22A, No. 2, October 8, 1930, p. 15.

This species is most closely allied to *P. rossi*, but has fewer spines, and these are limited mainly to the anterior half of

the pronotum, and with a relatively few on the fore-femora. The sides of the thorax are granular, rather than spiny, and the edges of the pronotum and abdomen are not as sharply toothed. The lateral notch is larger and the posterior lobe is more sharply raised and pointed (Figs. 25 and 26).

Twenty specimens were examined, all from Mexico.

***Phymata rossi* new species.**

(Figs. 27 and 28.)

MALE:

Size and General Color.—Length of body, 7 to 8 mm. Width of prothorax, 2.9 to 3 mm. Head dark brown and black on top, light brown on the sides. Antennae same as the sides, with the terminal segment slightly darker, and with a distinct sheen present. Pronotum varying shades of brown, the darkest being found at the tips of the posterior lobe. Scutellum a medium brown. Sides of thorax light brown. Legs the same color except the femora, which are a reddish brown. Hemelytra dark with a very pale band across the middle. Membrane brown. First, second and third connexiva yellowish, fourth and basal half of fifth black, the remaining connexiva yellow except for a dark spot on either side of the last segment. Ventral surface of abdomen yellowish except for a continuation of the dark fourth and fifth connexiva, which extends slightly upon the abdomen.

Head and Antennae.—Frontal processes upturned, usually projecting slightly beyond the first antennal segment and with a small notch between them. Ocellar processes medium in length, with several branches. Preocellar processes small and branching. Head covered with small spines on all the surface. Antennae with the terminal segment about as long as the preceding two taken together.

Thorax and Appendages.—Anterior half of pronotum with many spine-like projections, the posterior half with scattered ones. These also occur along the edges, producing a toothed effect. Anterior lobe gently widening. Lateral notch long and shallow (Figs. 27 and 28). Posterior lobe with distinct, sharp lateral processes and sharp posterior corners. Longitudinal ridges slender and only slightly raised. Sides of thorax with many of the spines found above, these also continuing on the coxae, trochanters and femora of all the legs, outer surface of the front femora thickly covered with them, those on the femora of the other legs in rows along each edge. Corium of the wings with a few scattered spines. Scutellum with a narrow, sharp margin trimmed with small spines. The cross-shaped center design is also studded with these spines.

Abdomen.—Edges of connexiva with spines similar to edges of pronotum but to a lesser degree. Posterior corners of first three connexiva projecting in small sharp points. The fourth also projects slightly and sharply. There is a gradual widening of the abdomen to the widest point. The dorsal and ventral surfaces have small granules and a few very small scattered spines.

FEMALE:

Length, 8 to 9 mm. Width of pronotum, 3 to 3.5 mm. Color as in the males, but with the dark colors replaced by a lighter brown. Terminal segment of antennae a little longer than the third segment. Abdomen more rounding. Otherwise as in the male.

Holotype.—♂, Huachaca Mts., Arizona, August 8, 1927 (R. H. Beamer). Deposited in the collection of the University of Kansas, Lawrence.

Allotype.—♀, same data as the holotype.

Paratypes.—2 ♀ ♀, same data as holotype and allotype; 1 ♀, Huachaca Mts., Arizona, July 28, 1907; 2 ♂ ♂, 2 ♀ ♀, Santa Rita Mts., Arizona, June-July (F. H. Snow); 4 ♂ ♂, 1 ♀, Arizona; 1 ♂, 1 ♀, Yavapai Co., Arizona, August 9, 1927 (P. A. Read); 1 ♀, Zion Natl. Park, Utah, Aug. 13, 1929 (R. H. Beamer); 1 ♂, West side of Organ Mts., New Mexico, July (E. O. Wooton). Deposited in the collections of the University of Kansas, Lawrence; Cornell University, Ithaca, New York; Ohio State University; Stanford University, Palo Alto, California; Iowa State College, Ames; and the author.

This species is most closely related to *P. granulosa* Handlirsch but is slightly smaller, and has the spine-like projections more generally scattered over the entire body. The forelegs are more thickly covered with setiferous granules. The lateral notch is smaller in both directions, and the posterior lobe is not as sharply raised or pointed.

***Phymata borica* new species.**

(Figs. 29 and 30.)

MALE:

Size and General Color.—Length, 8 mm. Width of pronotum, 2.8–3 mm. Color: Basal part of the head black or dark brown, the rest a medium brown. Antennae medium brown with the terminal segment darker. Sides of head and all of the ventral parts a greenish yellow. In older specimens this is more of a reddish brown. Pronotum is somewhat mottled with black, brown, and buff. Scutellum a light yellow or brown. Corium dark brown with light band. Under the wings a dark design is found. Abdomen mainly a greenish yellow with the usual dark band on all of the fourth, and the basal half of the fifth connexiva. First, second, and third connexiva may have a small dark spot at the basal edge, or not. There is a small dark spot on each side of the sixth connexivum. These dark areas show on the ventral surface.

Head and Antennae.—Frontal processes may extend slightly beyond the first antennal segment, or not. Notch between them may be distinct, or may be obliterated. Ocellar processes distinct and stout.

Preocellar processes small and indistinct. Terminal segment of antennae almost as long as the preceding two united. Median part of the dorsal surface of the head almost smooth, the rest of the head with fine granules.

Thorax and Appendages.—Pronotum characterized by the subquadrate shape. Lateral notch very small, and the posterior lobe hardly raising or flaring (Figs. 29 and 30). Lateral process blunt or slightly pointed. Posterior corner distinct. Longitudinal ridges almost smooth, a few granules at the anterior end. They are only slightly raised. Granulation on the pronotum is slight, and limited to the median part of the anterior lobe. On the sides of the thorax the granulation is variable and the granules small. Femora of forelegs almost smooth, a row of small granules occurring on the upper edge. Coxae and trochanters of all legs slightly granular. Femora of the middle and hind legs with a row of small granules on the upper and lower edges. Scutellum as wide as long, with a narrow rim. The raised central area with scattered granules.

Abdomen gently tapering to widest point. The connexiva almost even or only slightly projecting. The fourth connexivum only slightly projecting, and in some specimens somewhat rounded.

FEMALE:

Length, 8.5 to 9 mm. Width of pronotum, 3 to 3.5 mm. Colors lighter than in the male. Abdomen somewhat more rounding. Terminal antennal segment about three-fourths as long as the preceding two united. Otherwise as in the male.

Holotype.—♂, Zion National Park, Utah, July 13, 1929 (R. H. Beamer). Deposited in the collection of the University of Kansas, Lawrence.

Allotype.—♀, Chiric Mts., Arizona. Deposited in the collection of Cornell University, Ithaca, New York.

Paratypes.—2 ♂♂, 3 ♀♀, same data as allotype, two of them dated September 6, 1897; 1 ♀, Arizona (C. F. Baker); 2 ♂♂, Pocatella, Idaho; 1 ♂, Arizona, August, 1902 (F. H. Snow); 2 ♂♂, Glenwood Springs, Colorado (Wickham); 1 ♂, Dixie, Utah, September 10, 1915 (E. D. Ball). Distributed in the collections of Cornell University; University of Kansas; U. S. National Museum; University of Nebraska; H. G. Barber; Agricultural Experiment Station, Tucson, Arizona; and the author.

This species might be confused with some forms of *P. pennsylvanica coloradensis* but can be separated from them by the smaller size; the more reddish brown color; the flattened pronotum with a very small lateral notch; and the shorter, thicker ocellar processes.

***Phymata salicis* Cockerell.**

(Figs. 31 and 32.)

Phymata erosa salicis Cockerell, Entomologist, XXXIII, 1900, p. 66.

On the basis of Melin's discussion of *P. erosa* L. this subspecies is being raised to specific rank. The closest allied form observed is *P. metcalfi* (Figs. 33 and 34). *P. salicis* Cockerell may be distinguished from this allied form by the more rounding posterior lobe, and the more open lateral notch of the pronotum (Figs. 31 and 32), and by the longer and more pointed frontal processes of the head.

Thirty specimens were examined, all from Arizona and California.

***Phymata metcalfi* new species.**

(Figs. 33 and 34.)

MALE:

Size and General Color.—Length, 7.5 to 8 mm. Width of pronotum, 2.8 to 3 mm. Color in specimens collected July 28, 1930, as follows: Head greenish with black ocellar processes and base, and a dark margin. Antennae greenish with the terminal segment brownish. Sides and front of head light brown. Pronotum greenish and marked with dark brown or black. The greenish color forming a margin across the anterior part and along the sides, where it is stopped by an oblique dark band on the anterior lobe. Lateral notch margined by green. Posterior lobe dark except near the lateral notch and just in front of the scutellum. Longitudinal ridges and an area on each side, greenish. Lateral aspect buff with the legs brown or greenish. The green shows up particularly on the second and third pairs of legs and on the tibiae of the forelegs. Scutellum light green. Corium brownish on the basal half with the rest pale green. Abdomen light brown with a dark band on the fourth and the basal part of the fifth connexiva. This continues over the edge and is found ventrally on the connexiva. Remainder of the abdomen, ventrally, is light buff or yellowish. In older specimens the green has faded into a yellowish-brown, and the darker parts have become correspondingly lighter in color.

Head and Antennae.—Frontal processes more or less blunt and projecting slightly beyond the first antennal segment. The notch between them varies considerably, but is usually rather shallow. Ocellar processes quite long and distinct. Preocellar processes also distinct but shorter. Terminal segment of antennae about 0.8 as long as the preceding two taken together.

Thorax and Appendages.—Pronotum with a few very small granules located mainly on the anterior lobe. Anterior lobe gently rounding to the lateral notch, which is rather small both in length and depth. Posterior lobe with a distinct lateral process and posterior corner (Figs. 33 and 34). Longitudinal ridges slightly raised and enlarging very little at the anterior part. Sides of the thorax with very few

granules, these occurring mainly along the edges of the sclerites. Legs with few scattered granules, the fore-femora smooth on the side, and with a row of small knobs on the upper edge. Scutellum with a thin, sharp, margin, and with the center design granular on the raised portions.

Abdomen with small scattered granules on the upper and lower surfaces. Tapering gently to the widest point. First three connexiva extending very slightly at the posterior corner, or not at all. The fourth extending in an acute point.

FEMALE:

Length, 8.2 to 9 mm. Width of pronotum, 3 to 3.5 mm. Color a light green, or yellowish in older specimens, over the entire body. The darker markings are not as prominent as in the males. Fourth segment of antennae about seven-tenths as long as second and third united. Otherwise as in the male.

Holotype.—♂, Summer Lake, Lake Co., Oregon, July 28, 1930 (H. A. Scullen). Deposited in the collection of the Oregon Agricultural College, Corvallis, Oregon.

Allotype.—♀, same data as holotype.

Paratypes.—3 ♂♂, 1 ♀, same data as holotype and allotype; 1 ♂, 2 ♀♀, Ione, Oregon, Aug. 12 (Currin); 2 ♂♂, 1 ♀, Umatilla, Oregon, July 21, 1914 (H. F. Wilson); 1 ♂, 1 ♀, Lillooett, B. C., October 2, 1918. Deposited in the collections of the Oregon Agricultural College, Corvallis; H. M. Parshley, Northampton, Massachusetts; and the author.

This species resembles *P. salicis* Cockerell but can be differentiated from it by the more pointed and sharply upturned posterior lobe of the pronotum, by the less sharply pointed and less projecting frontal processes, the shorter lateral notch, the wider prothorax and abdomen, and the longer fourth antennal segment.

***Phymata severini* Handlirsch.**

(Figs. 35 and 36.)

Phymata erosa severini Handlirsch, Ann. K. K. Nat. Hofm., Wien, XII, 1897, p. 164.
Phymata severini Handlirsch, Melin, Arkiv for Zoologi, Band 22A, No. 2, October 8, 1930, p. 8.

This species is closely allied to *P. pacifica* but may be separated from the two subspecies in that group by the following characters. Pronotum as seen from above has rounding or very bluntly pointed posterior lobes (Figs. 35 and 36), whereas in *pacifica* the lateral process is distinctly pointed. Anterior lobe is somewhat more rounding laterally than in *pacifica*.

Tips of connexiva project more distinctly and in small points. Edges of last three connexiva somewhat sinuate, in *pacifica* broadly rounding. Six specimens were studied, all from Mexico.

***Phymata pacifica* new species.**

(Figs. 37 and 38.)

MALE:

Size and General Color.—Length, 6.5 to 7.5 mm. Width of pronotum, 2.8 to 3 mm. Color in specimens collected in 1929 as follows: Base of head to, and including the ocellar processes, dark brown or black studded with light colored granules. Remainder of head usually a pale cream color, in some a tinge of brown on the dorsal surface. Antennae with the first three segments pale, and the fourth varying shades of brown, but darker than the others. Anterior lobe of pronotum pale cream color, except for a small brown spot on the middle of the edges. Posterior lobe with this same light color along the margins reaching nearly to the lateral process. The posterior margin is also light, as is the entire scutellum. Remainder of pronotum, dorsally, is a reddish brown. Sides of the thorax, and the appendages, are similar to the sides of the head. Corium medium brown with a band that is paler and pinkish. Membrane is brown. Abdomen is yellow-buff, except for a reddish brown band on the fourth and basal half of the fifth connexiva. This band extends underneath a short distance.

Head and Antennae.—Head covered with many small, light colored granules. Frontal processes extend slightly beyond the first antennal segment, and are upturned. From the dorsal aspect, they have a sharp, angular notch between them, and are slightly rounding on the lateral edges. Ocellar processes short and rather heavy. Preocellar processes small, their light color making them indistinct. Fourth segment of antennae 0.8 to 0.9 as long as the second and third together.

Thorax and Appendages.—Pronotum granulate on the anterior lobe, and weakly punctate on the posterior lobe. Anterior lobe rounding, posterior lobe with sharp lateral process, and distinct posterior corner (Figs. 37 and 38). Longitudinal ridges thin, but distinct; slightly granular on the anterior tip. Sides are quite granulate, with small granules, but the appendages are practically devoid of any. Scutellum with a thin rim, the raised portion in the inner part is irregularly granulate.

Abdomen almost smooth, a very few scattered granules being present. Tapers gradually to the widest point. Posterior points of the first three connexiva projecting slightly, and bluntly. Fourth connexiva continuing the line of the first three. Ventral surface is somewhat shiny and with a few very small granules.

FEMALE:

Length, 7.3 to 8 mm. Width of pronotum, 3 to 3.5 mm. Color as in the male, except that the darker areas as found in the male are paler in this sex. Fourth segment of antennae about six-tenths to seven-tenths as long as 3 and 2 united. Otherwise as in the male.

Holotype.—♂, San Diego Co., California, July 4, 1929 (R. H. Beamer). Deposited in the collection of the University of Kansas, Lawrence.

Allotype.—♀, Alpine, California, July 9, 1929 (R. H. Beamer). Deposited with holotype.

Paratypes.—1 ♂, same data as holotype; 1 ♂, 1 ♀, same data as allotype; 1 ♂, San Jacinto Mts., California, July 21, 1929 (R. H. Beamer); 2 ♂♂, 1 ♀, Sonoma Co., California; 1 ♂, San Francisco, California; 1 ♂, Los Angeles Co., California; 1 ♂, Bakersfield, California, August 19–20, 1917 (R. C. Shannon); 1 ♂, 1 ♀, Claremont, California (Baker); 1 ♀, Orange Co., California; 1 ♂, 1 ♀, Tamalpais, California, August 5, 1915 (VanDuzee); 1 ♀, Coahuila, San Diego Co., California, August 18, 1914 (J. C. Bradley); 1 ♀, Ontario, California; 2 ♀♀, San Mateo Co., California; 1 ♀, California; 4 ♂♂, 9 ♀♀, Auburn, California, August 1915 and 1916 (L. Bruner); 1 ♂, 1 ♀, Tamalpais, California; 1 ♀, Giant Forest, California, July 28, 1929 (R. H. Beamer); 2 ♂♂, 1 ♀, San Margarita, California, August 6, 1912 (E. D. Ball); 1 ♂, 1 ♀, Orange Co., California, July 14, 1929 (R. H. Beamer); 1 ♂, Southern California; 1 ♀, Orange Co., California (E. O. Essig). Deposited in the collections of the University of Kansas; Ohio State University; Cornell University, Ithaca, New York; University of Nebraska; H. M. Parshley; Agricultural Experiment Station, Tucson, Arizona; Stanford University; University of California; Agricultural Experiment Station, Ft. Collins, Colorado; R. L. Usinger; and the author.

This species is allied to *P. severini* Handlirsch but differs in having sharper points to the posterior lobe of the pronotum and a more rounding abdomen, which does not taper as much in the last three segments as does *severini*. Prosternal processes are finer. Top of head has a rougher appearance.

***Phymata pacifica* new subspecies *stanfordi*.**

(Figs. 39 and 40.)

MALE:

Size and General Color.—Length, 6.8 to 7.8 mm. Width of pronotum, 2.5 to 3 mm. Color: Head black or dark brown from the base to the ocellar processes and a marginal black line to the tips of the frontal processes. Center part light brown. Antennae light reddish brown for the first three segments, the fourth being darker. Pronotum chiefly a light buff with black markings on the edge of the

anterior lobe about the center, and the edge of the posterior lobe. Sides of the head and thorax a light buff with a reddish tinge. Appendages the same, except the tibiae of the forelegs and the tarsi of all of them, which are green. Scutellum a light buff. Corium a medium brown for the basal half and lighter the rest of the distance. Abdomen only slightly darker than the pronotum for the most part. Fourth connexivum darker, with a light spot, sometimes elongating into a streak, on it. Basal part of fifth connexivum dark. A dark spot on each side of the last connexivum. Ventrally, the abdomen is about the same color as the fore part, but sometimes shows a slightly redder tinge. The dark markings on the fourth, fifth and sixth connexiva show underneath also. In older specimens the customary fading takes place, green showing yellow, and browns becoming lighter and more yellowish.

Body and Appendages as in *pacifica*, the outstanding difference being in the amount of granulation on the dorsal and ventral surfaces. In this subspecies the granulation is noticed readily, particularly from the lateral aspect, and is shown markedly on the forelegs, as well as the others, and on the ventral surface of the abdomen. Coloration is markedly different, in *pacifica* the light areas being a pale cream color, while in this one those areas are a light buff.

Holotype.—♂, Stanford University, California, August 29, 1928 (Carl Duncan). Deposited in the collection of Stanford University.

Allotype.—♀, same locality and collector as holotype. August 18, 1930.

Paratypes.—6 ♂♂, 6 ♀♀, same locality as holotype and allotype September, 1897 (Johnson), August 4 and 13, 1928, September 1, 1929, August 23–25, 1930 (Carl Duncan), and June, 1920; 3 ♀♀, Palo Alto, California, September, 1929 (T. Zschakke); 3 ♂♂, Santa Rosa, California, July, August, September, 1899; 3 ♀♀, Oakland Recreation Camp, California, July 20, 1928 (R. L. Usinger); 1 ♂, 1 ♀ Laguna Mts., California, July 6, 1929 (P. W. Oman); 1 ♂, 1 ♀, Santa Clara, California; 1 ♀, Mariposa Co., California, June 17, 1914; 1 ♂, Santa Cruz Mts., California; 1 ♂, Sacramento, California; 1 ♂, Mt. View, California; 1 ♂, Walnut Creek, California, July 1, 1927 (R. L. Usinger). Distributed in the collections of Stanford University; Agricultural Experiment Station, Tucson, Arizona; Iowa State College; University of California; University of Kansas; Oregon Agricultural College; Ohio State University; R. L. Usinger; and the author.

Phymata albopicta Handlirsch.

(Fig. 10.)

Phymata albopicta Handlirsch, Ann. K. K. Hofm., Wien, XII, 1897, p. 151.

This small species may be told by the flaring abdomen with the first to third connexiva extending in distinct knobs, the fourth widely extending, and the wing membrane having many small closed cells.

Only two specimens were represented, both from Mexico.

Phymata noualhieri Handlirsch.

(Fig. 16.)

Phymata noualhieri Handlirsch, Ann. K. K. Nat. Hofm., Wien, XII, 1897, p. 153.

This species differs from any other North American form studied, and can be recognized by the thick pronotum which is not raised along the edges and is only slightly wider behind than at the front; by the three-lobed fourth connexivum, with the middle lobe the largest; and by the interweaving veins of the membrane, forming closed cells of various sizes.

Five specimens were studied from the following states: North Carolina, Georgia, Florida, and Arizona.

Phymata vicina Handlirsch.

(Figs. 13 and 14.)

Phymata vicina Handlirsch, Ann. K. K. Nat. Hofm., Wien, XII, 1897, p. 150.

This species is allied to *P. luxa* and can be distinguished from the latter form by the color combination of black and white. The veins in the wing membrane are very numerous and fine and do not form closed cells towards the apex as they do in *P. luxa*.

The states from which representatives observed occurred were: Massachusetts, Connecticut, New Jersey, Virginia, Illinois, South Dakota, Nebraska, Kansas, Texas, Arizona, Colorado, Utah, and California. Thirty-five specimens were studied.

Phymata luxa new species.

(Figs. 11 and 12.)

MALE:

Size and General Color.—Length, 5 to 5.6 mm. Width of pronotum, 1.6 to 2 mm. Head mostly brown, medium on top, usually somewhat lighter on the sides. There may be a black mark at the base of the head, and the antennal groove may be black. Antennae the same color as the sides of the head and thorax. Pronotum mottled with two shades of brown, one medium, the other lighter. Scutellum medium brown. Sides of thorax light buff in some, and a reddish brown in

others. Legs same as the sides, the middle and hind femora sometimes mottled with darker. Corium somewhat variable, being a mixture of medium or darker brown with a very pale, almost white color, which may appear as a band, as a mottling, or as the color of the entire basal half. In all variations there are small whitish granules scattered in varying numbers over the corium. Abdomen varies from an almost white or cream color to a buff as the basic color. It is marked with the customary band on connexiva four and five, and has small dark spots along the edges of the connexiva. Underside of the abdomen about the same as the thorax, sometimes lighter.

Head and Antennae.—Frontal processes bluntly rounding, with a distinct notch between them. They extend distinctly beyond the first antennal segment. Ocellar processes appear as rather thick, granular swellings. Preocellar processes are difficult to observe from the dorsal aspect, but from the side they can be seen as small, almost flat structures. Terminal segment of antennae as long or slightly longer than the preceding two united. The head is quite thickly covered with granules.

Thorax and appendages.—Pronotum with no lateral notch, and without a distinct flare in the posterior part (Figs. 11 and 12). The anterior corners rather long and sharp, the lateral process distinct but blunt, and the posterior corners blunt or sharp. Longitudinal ridges only slightly raised, and smooth, except for a few granules at the anterior end. Very few granules on the pronotum and most of them in the middle of the anterior half. Posterior half rather coarsely punctate. Corium with a varying number of small whitish granules scattered over the surface. Membrane with a varying number of closed cells toward the apex. Sides of the thorax irregularly granulate. Coxae and trochanters of all the legs somewhat granulate. Fore-femora and tibiae smooth, the femora of the middle and hind legs with a row of conspicuous granules on the upper and lower edges. Fore-femora appear quite thin. Scutellum with a thin margin trimmed irregularly with small granules on the outer edges. Central raised portion with a distinct raised ridge, and irregularly granulose.

Abdomen tapering gently to the widest part. The first three connexiva with small, knob-like projections at the posterior corners. The fourth projecting slightly and bluntly pointed.

FEMALE:

Length, 6.2 mm. Width of pronotum, 2.2 mm. Colors somewhat lighter; the terminal antennal segment three-fourths as long as the preceding two united; abdomen more rounding. Otherwise as in the male.

Holotype.—♂, Del Rio, Texas, June 22, 1927 (Wickham). Deposited in the collection of the Ohio State University, Columbus.

Allotype.—♀, Colorado. Deposited in the collection of the Colorado Agricultural College, Fort Collins.

Paratypes.—1 ♂, Colorado; 1 ♂, Huachaca Mts., Arizona, June 15, 1930 (E. D. Ball); 1 ♂, San Rita Mts., Arizona, June 11, 1930 (E. D. Ball). Distributed in the collections of the Arizona Agricultural Experiment Station, Tucson; Colorado Agricultural Experiment Station, Fort Collins; and the author.

This species is most closely related to *P. vicina* Handlirsch but is more slender, smaller, and the points of the connexiva much less projecting. The closed cells in the wing membrane are also distinctive. The abdomen is more tapering than in *vicina*.

Genus *Macrocephalus* Swederus.

KEY TO SPECIES.

1. Small species, 6.5 mm. or less in length..... 2
Larger species, 7 mm. or more in length..... 4
2. Scutellum coarsely punctured over the entire surface..... 3
Scutellum coarsely punctured on the basal third, the remainder much more finely punctured; conspicuous spine-like granules on the pronotum, sides of thorax, fore-femora, and elsewhere; occurring in Arizona, *uhleri* Handl.
3. Anterior half and lateral edges of pronotum with distinct pointed granules; color in male a mottling of black and yellowish on the scutellum, female less so, and often with no dark patches; occurring in Mexico. *stali* Handl.
Anterior half and lateral edges of pronotum with small round granules; color on the scutellum of male may be yellow with a black median stripe, or only yellow, female usually without the black stripe; widely distributed..... *prehensilis* (Fabr.)
4. A prominently raised knob or elevation at the anterior end of each longitudinal ridge; a prominent somewhat punctate subtriangular or arrow-shaped callus on the scutellum; color mottled dark and light; occurring in California..... *barberi* n. sp.
Longitudinal ridges with very small knobs or none; callus of scutellum of various shapes..... 5
5. Callus of scutellum sub-triangular or arrow-shaped and quite thickly punctate with very small punctures; terminal antennal segment in male less than $1\frac{1}{2}$ times as long as the preceding two united, in the female about $1\frac{1}{4}$ times; occurring in Arizona..... *doranne* n. sp.
Callus of scutellum other than the above shape, fusiform or spear-shaped; or a single median carina..... 6
6. Callus of scutellum a varying fusiform or spear-shape; callus at its broadest part, covering one-third or more of the width of the scutellum... 7
Callus of scutellum reduced to a single median carina, slightly widening at base..... 8
7. Second and third connexiva as seen from above are as wide as long; occurring in Florida..... *cimicoides* Swed.
Second and third connexiva as seen from above are longer than wide; occurring in Mexico, Panama, Texas..... *notatus* Westw.
8. Slender, elongate species; abdomen barely visible from above; posterior lobe of pronotum with a single sharp point on either side smooth and punctate on scutellum; occurs in Panama..... *angustatus* Champ.
Shorter, broader species; abdomen roundly chordate; surface of scutellum prominently reticulate with raised lines; pronotum granulate, posterior lobe bilobed; occurs in Arizona..... *arizonicus* Ckll.

Macrocephalus cimicoides Swederus.

Macrocephalus cimicoides auctt. (See VanDuzee, 1917).

Resembles *M. notatus* Westwood very closely. The abdomen in both sexes is wider and more heart-shaped than in *cimicoides*. The second and third segments of the connexiva in this species as seen from the dorsal aspect are as wide as long.

Nine specimens were studied, all from Florida.

Macrocephalus notatus Westwood.

Macrocephalus notatus auctt. (See VanDuzee, 1917).

Resembles *M. cimicoides* Swederus very closely. The abdomen is not as widely flaring and not as distinctly heart-shaped as in *M. cimicoides*. It may be recognized by the fact that the second and third connexiva, as seen from the dorsal aspect, are longer than wide.

Fourteen specimens were studied, from Texas, Mexico, Guatemala, and Canal Zone, Panama.

Macrocephalus manicatus (Fabricius).

Syrts manicatus Fabricius, Syst. Rhyng., 1803. p. 123.

Handlirsch lists this as a North American species, but none were present in the collections examined by the writer. It is closely allied to *cimicoides* Swed. and *notatus* Westw., but may be distinguished from them by the fact that the scutellar callus at its widest point is less than $\frac{1}{3}$ as wide as the scutellum.

Macrocephalus dorannæ new species.**MALE:**

Size and General Color.—Length of body, 7 to 8 mm. Width of prothorax, 2.7 to 3.2 mm. Width of abdomen, 3.2 to 3.9 mm. Color of dorsal surface mainly black or dark brown with grayish or ochraceous, small, smooth granules over the entire surface. Edges of anterior lobe of pronotum, the arrow or spear-headed callus on scutellum, and the first connexivum ochraceous buff. Second and third connexiva black or dark brown. Remainder of connexiva buff with varying amounts of dark color. Exposed part of corium dark brown or black. From the side the colors seen are light buff, mottled with brown. Coxae, trochanters and femora of all legs darker and spotted. Tibiae of fore-legs dark, and of mid and hind legs light brown. Abdomen with lateral portions just under the connexiva a reddish brown, remainder of ventral portion lighter. Antennae dark brown or black, except at the joints, which are light, and a light spot about the middle of the terminal segment.

In fresh specimens the black or dark brown may be replaced by a reddish brown wherever it is to be found, and the scutellum, antennae and legs have a greenish color. The granules do not show up as distinctly in the fresh specimens.

Head and Antennae.—Head typical of the genus, covered with very small, smooth granules. Measurements of the antennae are: second segment about one and one-fifth times as long as wide, third about one and three-fifths times as long as wide, fourth approximately twice as long as wide, and the fourth from one and one-fifth to one and three-eighths as long as two and three combined.

Thorax and Appendages.—Anterior lobe of the pronotum gently slanting to the transverse groove then widening abruptly to form the posterior lobe, which has a distinct lateral process. A small, sharp notch separates this from the posterior corner, which is slightly more rounded. Longitudinal ridges prominent from the transverse groove posteriorly to about the middle of the lobe, where they gradually diminish. Anterior lobe appears smooth beneath the granules, whereas the posterior one is slightly roughened. Sides of thorax thickly covered with small granules. Forelegs with a few larger granules on the coxa, trochanter and femur. Middle and hind legs with large and prominent granules on the coxae, trochanters, and femora, the tibiae with finer granules. Scutellum impressed at the base with a rounding area immediately posterior to this impression. Somewhat irregularly punctate in the impressed area and with very few granules. Callus very distinctive, shaped like an arrow-head, and very thickly punctate with very small punctures. Callus extends about one-half or slightly more across the scutellum, and from the base about two-thirds of the distance back. Many small granules cover the rest of the scutellum, but more occur on the callus.

Abdomen.—Chordate in shape, and thickly covered with granules on both surfaces.

FEMALE:

Length, 8.2 to 9.2 mm. Width of prothorax, 3 to 3.5 mm. Width of abdomen, 4.2 to 4.5 mm. Color in specimens observed, lighter than in male. These specimens apparently have been killed only a year or less and in color resemble the males killed in 1930, so that in fresh specimens the two sexes would be the same in coloration. Otherwise as in the male.

Holotype.—♂, Patagonia, Arizona, September 20, 1930 (E. D. Ball). Deposited in the collection of the Agricultural Experiment Station, Tucson, Arizona.

Allotype.—♀, same data as the holotype.

Paratypes.—7 ♂♂, Arizona; 1 ♂, Nogales, Arizona, October 8, 1898 (Koebele); 1 ♂, Salt River Hill, Arizona, September 26, 1924 (Hunter); 1 ♂, 4 ♀♀, same data as holotype and allotype; 2 ♀♀, Arizona; 1 ♀, Baboquivaria Mts., Arizona (F. H. Snow). Deposited in the collections of Agricultural Experi-

ment Station, Tucson, Arizona; U. S. National Museum; Cornell University, Ithaca, New York; Ohio State University, Columbus; University of Kansas, Lawrence; Stanford University, Palo Alto, California; and the author.

This species is allied to *M. cimicoides* and *M. notatus* and may be distinguished from them by the following characteristics. Callus of pronotum distinctly punctate, and spear or arrow-head shaped. Terminal antennal segment in the male less than $1\frac{1}{2}$ times as long as the second and third united; in the female about $1\frac{1}{4}$ times as long as the preceding two united.

***Macrocephalus arizonicus* Cockerell.**

Macrocephalus arizonicus Cockerell, Entomologist, XXXIII, 1900, p. 66.

This form is allied with *M. prehensilis* (Fabricius) but is larger; and has a very rough-finished appearance over the entire body due to a combination of punctures and reticulate raised lines over the pronotum and scutellum, and a noticeable granulation of the rest of the body.

Three specimens from Arizona were examined.

***Macrocephalus angustatus* Champion.**

Macrocephalus angustatus Champion, Biologia Centrali-Americana, Rhyncota-Heteroptera, Pt. 2, 1901, p. 59.

Elongate, slender species. The abdomen is barely visible from the dorsal view. The posterior lobe of the pronotum has one distinct sharp point on each side. Smoothly finished and shallowly punctate on the pronotum and scutellum.

One specimen from Ancon, Panama.

***Macrocephalus barberi* new species.**

MALE:

Size and General Color.—Length of body, 7 mm. Width of abdomen, 3.5 mm., scutellum approximately two times as long as wide. Ground color of the dorsal surface black or dark brown, with many tiny, smooth granules of a light color scattered over the surface, giving it a mottled appearance. Head black, fading to ochraceous on the sides, which are also mottled with darker areas. First, second, and third segments of antennae black with the exception of the joints, which are light. Fourth segment with a small dorsal spot that is dark, the rest being pale. Pronotum mainly black with the light granules grouped in some places making it appear mottled. Edges of the anterior lobe light ochraceous. Scutellum mottled and with an arrow-head shaped callus which is light at the anterior end and darker at the posterior.

Corium black with many light granules. Front connexiva entirely light colored, the remainder black with the light granules prominent, and the posterior tips of each slightly projecting and tipped with light ochraceous. Ventral surface pale ochraceous with dark spots on the thorax and coxae and femora of legs. Abdomen with a longitudinal row of small dark spots about half way up on each side.

Head and Antennae.—A slight swelling or elevation where the ocelli are located. Antennae rather short with a heavy terminal segment. Terminal segment two and one-fourth times as long as wide, third segment two times as long as wide, the terminal segment about one-fourth times as long as the preceding two taken together.

Thorax and Appendages.—Anterior lobe of pronotum widening gently to the posterior lobe which flares out abruptly and forms a transverse process, from which a slight curve leads to the rounded posterior corner. Longitudinal ridges plainly raised and converging anteriorly. Each ends in a distinct elevation or raised knob at the transverse groove. Top and sides of thorax, as well as legs, thickly covered with small, smooth granules. Fore tibiae and middle and hind tarsi without granules. Portion of corium which is exposed to view thickly set with small, smooth granules. Scutellum about 1.9 times as long as wide, quite deeply impressed near base, a prominent arrow or spear-shaped callus present for about one-half its length, and continuing posteriorly as a smooth, narrow median carina. The callus somewhat punctate, as is also the impressed area. The outer parts and the posterior third are quite thickly granulated.

Abdomen chordate and thickly covered with small granules on both surfaces.

FEMALE:

7.5 mm. long, 4.2 mm. across abdomen. Color mostly light with dark brown or black markings. The head with a small dark area around the ocelli and toward the front. Prothorax mostly light with dark spots variably scattered. Scutellum all light. Corium darker. Connexiva mottled with dark and light, the first connexivum as in male. Otherwise as the male.

Holotype.—♂, Fern Co., California. Deposited in the U. S. National Museum.

Allotype.—♀, Los Angeles Co., California, July. Deposited in the U. S. National Museum.

This species is medium in size, and differs from any of the specimens available for study. The roughness of the pronotum and the raised knobs or elevations on the longitudinal ridges make it distinctly different from our nearctic forms. It is probably allied to some of the Mexican or Central American species that are not included in this collection.

Macrocephalus prehensilis (Fabricius).

Syrtilis prehensilis Fabricius, Syst. Rhyngotorum, 1803, p. 123.

Macrocephalus prehensilis auctt. (See VanDuzee, 1917).

This small species is closely allied to *M. uhleri* Handlirsch. It can be easily distinguished from *M. uhleri*, however, by the fact that the coarse punctures on the scutellum do not diminish in size towards the apex, and also by the absence of spine-like granules on the pronotum, sides of the thorax, and the legs, the fore-femora particularly.

Specimens studied were from the following states: North Carolina, Alabama, Kentucky, Florida, Texas, Oklahoma, Arkansas, and Kansas. Forty specimens were examined.

Macrocephalus uhleri Handlirsch.

Macrocephalus uhleri Handlirsch, Verh. Zool.-Bot. Ges. Wien, XLVIII, 1898, p. 383.

The most closely allied form to this species is *M. prehensilis* (Fabricius) from which it can be differentiated by the prominent covering of spiny granules on the anterior half of the pronotum, the sides of the thorax, and on the legs. Another aid is the fact that the punctures at the base of the scutellum diminish very noticeably in size about one-third of the way back, and are much smaller over the remaining two-thirds.

A series of eighty specimens was observed, all from Arizona.

Macrocephalus stali Handlirsch.

Macrocephalus stali Handlirsch, Ann. K. K. Nat. Hofm., Wien, XII, 1897, p. 195.

This species is closely allied to *M. prehensilis* and *uhleri*. It is easily distinguished from *uhleri* because the scutellum in *stali* is coarsely punctate throughout, whereas *uhleri* is finely punctate on the apical two-thirds. *M. stali* may be separated from *prehensilis* by the pointed, elongate granules on the anterior lobe, and the edges of that lobe, of the pronotum. The color in the male *stali* is a mottled black and yellowish on the scutellum, while in *prehensilis* it is a black stripe along the median carina of the scutellum.

Four specimens from Mexico were studied.

BIBLIOGRAPHY.

- Blatchley, W. S. 1926. Phymatidae: in Heteroptera of Eastern North America. Nature Publishing Co., Indianapolis, pp. 503-510.
Champion, G. C. 1897. Phymatidae: in Biologia Centrali-Americana. Hemiptera-Heteroptera, Vol. 2, London, pp. 49-64, Pl. 4.

- Cockerell, T. D. A. 1900. New Insects from Arizona. Phymatidae, Entomologist, Vol. 33, p. 66.
- Handlirsch, A. 1897. Monographie der Phymatiden. Annalen des K. K. Naturhistorischen Hofmuseums, 12 Band, pp. 127-230.
1898. Zuie neue Phymatiden. Verhandlungen Zool.-Botan. Gsellschaft in Wien, Vol. 48, pp. 383-384.
- Melin, Douglas. 1930. Hemiptera from South and Central America. II. Arkiv for Zoologi, Stockholm, Band 22A, No. 2, pp. 1-40.
- Parshley, H. M. 1923. Phymatidae: in Hemiptera of Connecticut. Bulletin 34 of the State Geological and Natural History Survey, pp. 692-693.
1925. Bibliography of the North American Hemiptera-Heteroptera. Smith College Publications, Northampton, Massachusetts.
- Stal. 1876. Enumeratio Phymatidarum. Enumeratio Hemipterorum, Part V, Stockholm, pp. 131-136.
- VanDuzee, E. P. 1909. Observations on Hemiptera from Florida, Phymatidae. Bulletin of the Buffalo Society of Natural Sciences, Vol. 9, No. 2, pp. 174-175.
1914. A Preliminary List of the Hemiptera of San Diego County, California; Phymatidae. Transactions of the San Diego Society of Natural History, Vol. 2, No. 1, pp. 11-12.
1917. Phymatidae. Catalogue of the Hemiptera of America North of Mexico, pp. 225-231.

EXPLANATION OF PLATES.

(All figures of prothorax drawn to same scale.)

PLATE I.

- Fig. 1A. *Phymata* sp., technical terms, (Schematic).*
- Fig. 1B. *Phymata* sp., lateral aspect of prothorax, technical terms.

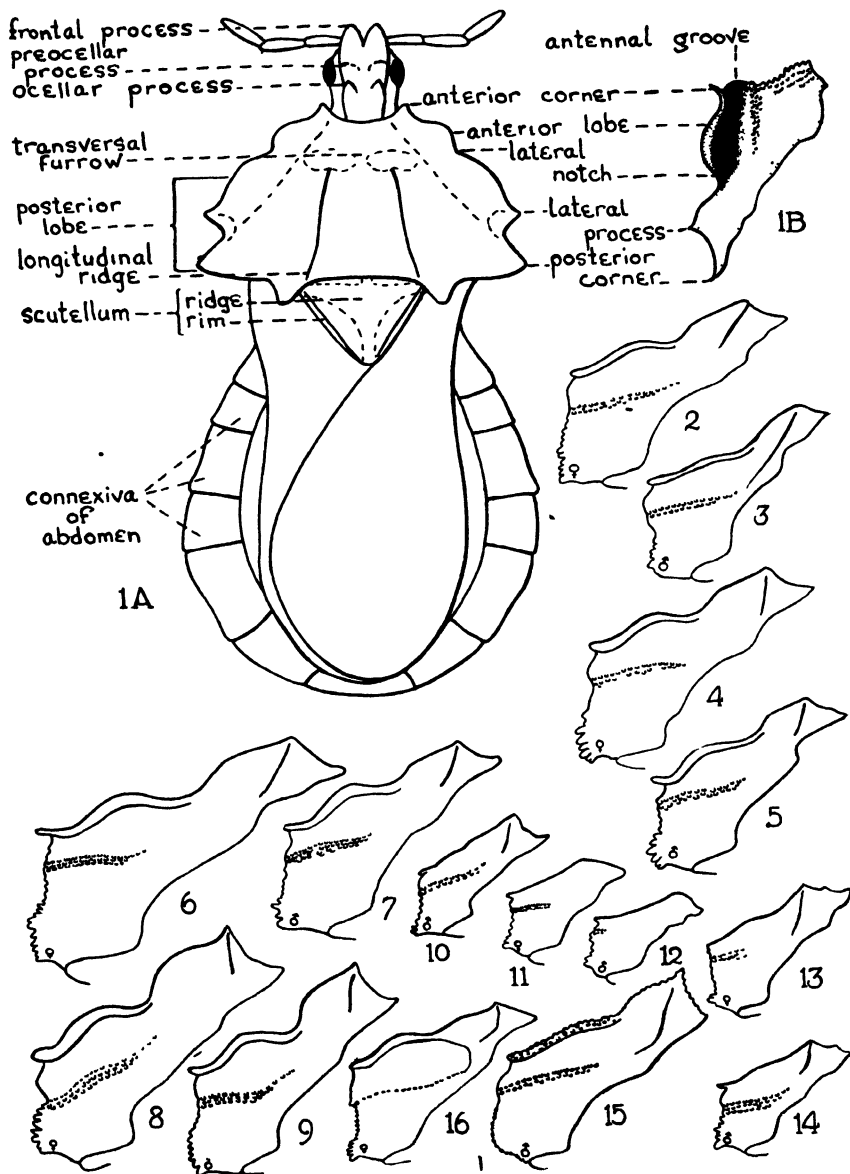
LATERAL ASPECT OF PROTHORAX.

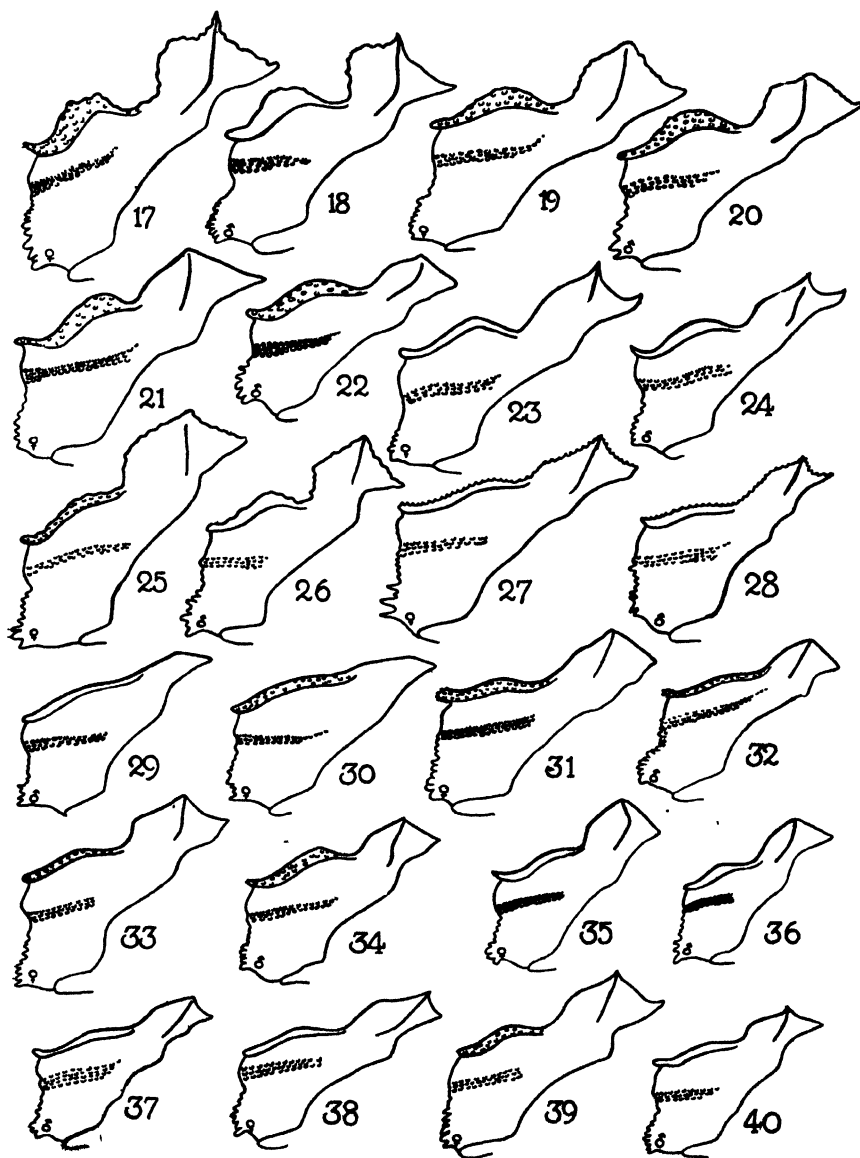
- | | |
|---|---------------------------------------|
| Fig. 2. <i>P. pennsylvanica</i> , ♀. | Fig. 10. <i>P. albopicta</i> , ♂. |
| Fig. 3. <i>P. pennsylvanica</i> , ♂. | Fig. 11. <i>P. luxa</i> , ♀. |
| Fig. 4. <i>P. pennsylvanica americana</i> , ♀. | Fig. 12. <i>P. luxa</i> , ♂. |
| Fig. 5. <i>P. pennsylvanica americana</i> , ♂. | Fig. 13. <i>P. vicina</i> , ♀. |
| Fig. 6. <i>P. pennsylvanica coloradensis</i> , ♀. | Fig. 14. <i>P. vicina</i> , ♂. |
| Fig. 7. <i>P. pennsylvanica coloradensis</i> , ♂. | Fig. 15. <i>P. arctostaphylæ</i> , ♂. |
| Fig. 8. <i>P. pennsylvanica coloradensis</i> , ♀. | Fig. 16. <i>P. noualhieri</i> , ♀. |
| Fig. 9. <i>P. pennsylvanica coloradensis</i> , ♂. | |

PLATE II.

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| Fig. 17. <i>P. fasciata</i> , ♀. | Fig. 29. <i>P. borica</i> , ♂. |
| Fig. 18. <i>P. fasciata</i> , ♂. | Fig. 30. <i>P. borica</i> , ♀. |
| Fig. 19. <i>P. fasciata georgiensis</i> , ♀. | Fig. 31. <i>P. salicis</i> , ♀. |
| Fig. 20. <i>P. fasciata georgiensis</i> , ♂. | Fig. 32. <i>P. salicis</i> , ♂. |
| Fig. 21. <i>P. fasciata georgiensis</i> , ♀. | Fig. 33. <i>P. metcalfi</i> , ♀. |
| Fig. 22. <i>P. fasciata georgiensis</i> , ♂. | Fig. 34. <i>P. metcalfi</i> , ♂. |
| Fig. 23. <i>P. mystica</i> , ♀. | Fig. 35. <i>P. severini</i> , ♀. |
| Fig. 24. <i>P. mystica</i> , ♂. | Fig. 36. <i>P. severini</i> , ♂. |
| Fig. 25. <i>P. granulosa</i> , ♀. | Fig. 37. <i>P. pacifica</i> , ♂. |
| Fig. 26. <i>P. granulosa</i> , ♂. | Fig. 38. <i>P. pacifica</i> , ♀. |
| Fig. 27. <i>P. rossi</i> , ♀. | Fig. 39. <i>P. pacifica stanfordi</i> , ♀. |
| Fig. 28. <i>P. rossi</i> , ♂. | Fig. 40. <i>P. pacifica stanfordi</i> , ♂. |

*Fig. 1A of Plate I modeled after Melin, 1930.





OBSERVATIONS ON CROP AND GIZZARD MOVEMENTS IN THE COCKROACH, PERIPLANETA FULGINOSA (SERV.).

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With the exception of a few incidental observations, the literature appears to contain no detailed description of movements occurring in the insect alimentary tract observed *in situ*. Vigorous movements of the proventriculus or gizzard (honey stopper) have been observed in the bee by Cheshire (1) and by Whitcomb and Wilson (2) among others. Hobson (3) and Ten Cate (4) have made studies on the effects of various drugs and electrolytes on the isolated fore-gut of *Dytiscus*, but such studies are comparatively few and usually do not include observations made upon the uninjured animals. The present paper is a report of observations on the movements of the alimentary tract, especially of crop and gizzard, of the intact cockroach, *Periplaneta fuliginosa* (Serv.).¹

METHOD AND MATERIAL.

The method of observation is quite simple, transmitted light having been frequently utilized by various investigators for other purposes, and can be readily used in connection with laboratory classes in insect physiology. It consists essentially of illuminating the body of the insect by means of a concentrated beam of light and observing the illuminated tract through a binocular dissecting microscope. The source of light is a carbon arc, or, better, a strong incandescent lamp bulb. The beam of light is passed through water to remove the heat (which with these sources of light is sufficient to kill the animal), reflected upward by a substage mirror and concentrated in the body of the insect by a substage condenser (from an ordinary compound microscope). The insect is enclosed between two glass slides, separated by walls of beeswax. The size of the chamber is adapted to the size of the insect.

¹The author is indebted to Mr. Robert Hale Nelson for the identification of this species, a tropical form found in greenhouses at Ames.

A thin layer of vaseline between the dorsal surface of the animal and the roof of the chamber facilitates observation.

The material consists of individuals of *Periplaneta fulginosa* whose flat bodies and comparatively light pigmentation adapt them to this method of observation, which may be applied to certain other species as well. The individuals used were from a single colony, kept under approximately constant environmental conditions (i.e., of food, temperature and humidity). The food consisted of banana or a mixture of banana and animal charcoal, the latter serving to increase the opacity of the food.

RESULTS.

Movements of the Fore-gut.

Observations of more than seventy insects in various stages of development indicate that in the apparently normal individual of this species movements of crop, gizzard and hind-gut may occur at quite different rates. The mid-gut is not easily observed by the present method. When the crop and gizzard are both vigorously active the rate of gizzard movement is usually greater than the rate of crop movement (peristalsis) while movements of the hind-gut are relatively infrequent. Variations of crop and gizzard movement are such, however, that the gizzard may appear at different times to be more or less active than the crop. The crop exhibits three types of movement: peristaltic contraction waves that move posteriorly, anti-peristaltic contraction waves that move anteriorly, and contractions involving the whole posterior third of the crop. The peristaltic waves originate, as a rule, in the esophageal or pharyngeal region; each wave appears as a constriction extending entirely around the esophagus or upper crop and then progresses posteriorly at a variable rate to disappear just anterior to the gizzard. Anti-peristaltic waves appear to consist of two kinds; waves identical in appearance to the peristaltic waves and progressing at approximately the same variable rate as the latter, and waves that seem to originate rhythmically, following upon the rhythmic contractions of the posterior third of the crop. The latter contractions themselves appear to be associated with rhythmic contractions of the gizzard, usually occurring just subsequent to contractions of the latter. The second type of anti-peristaltic wave often progresses at a more

rapid rate than the first type. Both types have been observed in the crop at the same time.

Peristaltic and anti-peristaltic waves may meet in the middle region of the crop, in which case (1) the two contractions may both disappear completely, (2) one of the waves may disappear while the other continues without modification, (3) the two waves may pass each other without obvious modification or (4) one wave may become stationary and continue its progressive movement after it has been passed by the other.

The gizzard exhibits active contractions and passive movements due to activity of the crop to which it is attached. At times the entire fore-gut is pulled vigorously in an anterior direction. Because gizzard contractions are less readily observed than those of the larger crop, an inexperienced observer finds it somewhat difficult to detect the former apart from the latter. The following observations indicate, however, that actual contraction of the latter does occur. Both the intact and excised gizzard have the same shape and general appearance; the "teeth" of the former appear as six dark spots, which converge during contraction and diverge during relaxation.² The contraction rate is at times decidedly different from the rate of crop movement (peristalsis). If a needle be thrust through the body wall into the contracting part, subsequent dissection shows that the needle does pierce the gizzard. Contraction of the excised gizzard, although of very infrequent occurrence, appears similar to the contraction of the organ observed *in situ*.

Contractions of the Gizzard.

When measured over short periods of time the rate of gizzard contraction appears to be fairly uniform. This is shown in Table I.

Each figure is the time required for five successive contractions to occur and is separated from the succeeding figure by a period of one or two minutes. Sometimes the rate is quite uniform as with animals 33, 19, and 29, but, usually, there appears to be a gradual but slight decrease in rate as the time of observation increases. The high initial rate is due possibly

²A single contraction of the gizzard consists of a definite contraction, in which the diameter of the part decreases, and of a definite relaxation, during which the diameter increases to a greater than normal value, after which the diameter returns to normal; at times the relaxation phase is more obvious than the contraction phase.

to general excitement of the animal produced by handling. There is no significant correlation between rate of contraction and body length and, presumably, none between contraction rate and stage of development. The rate is modified, however,

TABLE I.

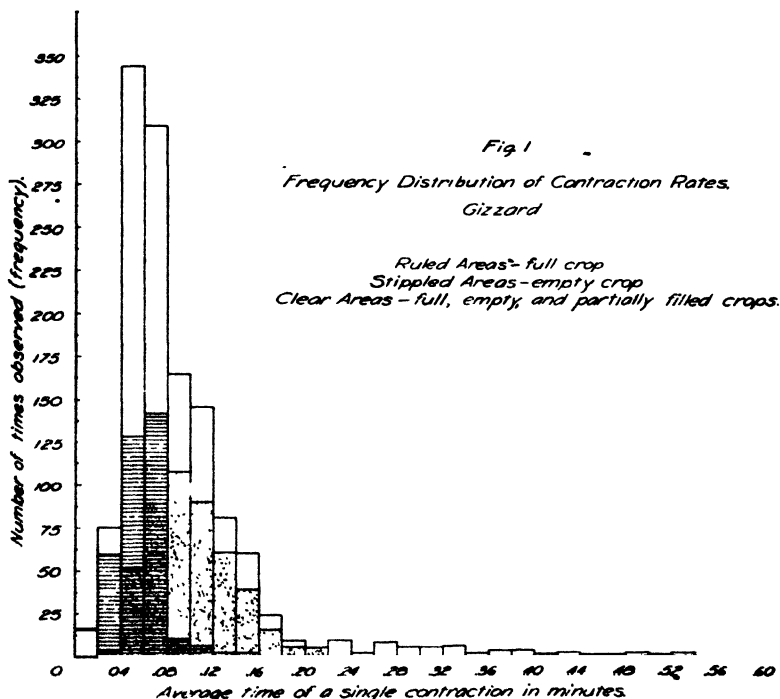
RATES OF GIZZARD CONTRACTION.

Each figure is the time (in minutes) required for five successive contractions to occur.

No. of Insect	4	8	20	25	27	29	19	22	32	33
Length (cm.)	2.6	?	1.2	1.6	2.6	3.0	2.0	0.8	2.9	3.1
Stage of Devel.	Nymph	Nymph	Nymph	Nymph	Nymph	Adult	Nymph	Nymph	Adult	Adult
Crop	Nearly empty	Partly filled	Empty, bloated	Partly filled	Full	Empty ?	Nearly empty	Full	Empty, bloated	Partly filled
	0.470	0.280	0.545	0.400	0.200	0.215	0.600	0.270	0.260	0.235
	0.600	0.270	0.480	0.405	0.195	0.230	0.615	0.270	0.270	0.230
	0.640	0.290	0.565	0.430	0.190	0.230	0.480	0.230	0.265	0.245
	0.403	0.275	0.600	0.425	0.195	0.235	0.400	0.270	0.270	0.260
	0.340	0.300	0.615	0.460	0.190	0.250	0.440	0.260	0.295	0.245
	0.340	0.290	0.440	0.470	0.190	0.230	0.400	0.260	0.315	0.255
	0.375	0.360	0.580	0.570	0.195	0.250	0.440	0.270	0.260	0.260
	0.335	0.400	0.455	0.450	0.190	0.255	0.450	0.275	0.270	0.260
	0.350	0.205	0.580	0.475	0.200	0.260	0.425	0.285	0.325	0.275
	0.370	0.215	0.360	0.455	0.195	0.255	0.400	0.300	0.285	0.270
	0.355	0.280	0.490	0.460	0.195	0.260	0.360	0.295	0.325	0.265
	0.345	0.240	0.535	0.510	0.205	0.255	0.345	0.290	0.355	0.280
	0.325	0.455	0.385	0.500	0.190	0.255	0.295	0.340	0.290	0.280
	0.325	0.290	0.495	0.500	0.195	0.250	0.330	0.300	0.515	0.275
	0.350	0.250	0.705	0.505	0.195	0.260	0.390	0.310	0.500	0.280
	0.350	0.210	0.605	0.500	0.195	0.260	0.410	0.350	0.490	0.280
	0.350	0.255	0.510	0.515	0.220	0.305	0.400	0.255	0.470	0.260
	0.330	0.330	0.580	0.520	0.190	0.265	0.480	0.370	0.420	0.290
	0.355	0.265	0.595	0.550	0.195	0.260	0.485	0.370	0.420	0.290
	0.310	0.345	0.700	0.515	0.195	0.255	0.410	0.375	0.480	0.290
	0.300	0.310	0.845	0.500	0.195	0.260	0.435	0.365	0.440	0.230
	0.310	0.435	0.620	0.510	0.195	0.275	0.550	0.380	0.380	0.290
	0.295	0.385	0.280	0.520	0.195	0.250	0.535	0.355	0.635	0.290
	0.300	0.270	0.460	0.495	0.205	0.260	0.470	0.355	0.545	0.260
	0.310	0.270	0.455	0.550	0.195	0.275	0.440	0.355	0.670	0.250
	0.310	0.265	0.560	0.560	0.200	0.290	0.390	0.370	0.405	0.295
	0.315	0.320	0.325		0.300	0.260	0.390	0.360	0.455	0.300
	0.280	0.240	0.410		0.190	0.255	0.465	0.360	0.900	0.280
	0.220	0.220	0.825		0.195	0.270	0.410	0.360	0.260	0.265
	0.295	0.245	0.525		0.195	0.275	0.445	0.310	1.200	0.260

during and subsequent to the ingestion of food. Several direct observations indicate that during ingestion the contraction rate decreases while immediately following ingestion the contraction rate increases several fold. The acceleratory

effect of ingested food on gizzard activity is also indicated by Figure 1 which shows the distribution of contraction rates; along the abscissa are the average times of a single contraction (based on measurements of five successive contractions); along the ordinate are frequencies with which given rates have been observed. The areas with horizontal lines represent animals having full crops, the stippled areas animals with empty crops and the unruled areas animals having partially filled crops.



The gizzard contractions are apparently affected by other factors also; at times and for no obvious cause, the contractions cease altogether for periods up to one minute or more; movement of the whole animal (as a struggle to escape) usually involves an initial decrease followed by an increase of contraction rate; extreme dorso-ventral pressure, as would be caused by an observation chamber of much too shallow depth, tends to decrease the rate and the degree of contraction; and contraction is influenced by the animal's nervous system. The latter relationship is indicated by the following observations.

Destruction of the region of the first thoracic ganglion between the first pair of legs results in immediate cessation of the normal gizzard contractions, although crop activity continues. Destruction of the second thoracic ganglion region between the second pair of legs produces an immediate paralysis of the posterior pairs of legs but does not paralyze the first pair and does not fully stop the gizzard contractions. The latter do not cease following destruction of the region between the third pair of legs. Removal of the head by complete section at the neck as well as drawing a thread tightly about the neck results in cessation of contractions. If, however, the thread is gradually tightened until the gizzard contractions *just* cease to occur and is then loosened without further injury to the animal the gizzard can be observed to resume its activity. Destruction of neck and head regions has not resulted in uniformly consistent results. In general, however, it has been found that cautery of the supra-esophageal region of the head and neck does not completely eliminate gizzard contractions although the intensity and rate of contraction seem to be lessened; destruction of the sub-esophageal region of the head and the postero-dorsal region of the neck (beneath the anterior margin of the pronotum) seems to have a still greater eliminative effect on gizzard activity. When dissected out through the thoracic body wall, the excised crop and gizzard do not exhibit obvious contractions when not immersed in fluid or when immersed in water or a one per-cent NaCl solution, even when stimulated by induced make, break or tetanizing currents of considerable strength; when, however, the head is pulled from the body, dragging the crop and gizzard with it, the crop shows much activity while the gizzard remains relatively inactive, showing at times only faint, infrequent contractions. The intact gizzard seems to be unresponsive to contact stimuli; this can be demonstrated by stimulating with a needle thrust through the body wall or down the lumen of the esophagus and crop.

DISCUSSION.

Most of the observations described above require little discussion. It is of some interest, however, that the crop and gizzard exhibit different physiological behaviors. Although the experiments just described offer no proof, they constitute

evidence that the normal activity of the roach gizzard is immediately dependent on the integrity of the animal's nervous system, especially the central nervous system in the region of the first thoracic ganglion, while the same does not hold true for the crop. This is of some importance in view of the fact that both the crop and gizzard are usually reported to be innervated by sympathetic nerves from the stomato-gastric nervous system, and in particular by nerves from the ventricular ganglion (located on the dorsal surface of the esophagus). It is, of course, quite possible that morphologically both the gizzard and crop may receive nerves from the sympathetic nervous system while the one and not the other may be functionally dependent on the central nervous system; it is necessary that further work be done before a complete explanation of the neurological relationships of the crop and gizzard becomes available.

SUMMARY.

- (1) A simple method of observing movements of the intact gut of certain insects is described.
- (2) Three types of crop movement may occur: Peristaltic contraction waves, anti-peristaltic waves and contractions involving the posterior third of the crop.
- (3) Contraction of the intact gizzard occurs in the normal individual of the species observed.
- (4) The rate of gizzard contraction may be quite uniform over relatively short periods but may be affected by a number of different factors, some of which are mentioned.
- (5) The normal activity of the gizzard appears to be dependent on the integrity of the animal's central nervous system, especially in the region of the first thoracic ganglion.
- (6) The normal activity of the crop does not appear to be dependent on the integrity of the animal's central nervous system.
- (7) The gizzard is relatively unresponsive to contact stimuli.

REFERENCES.

1. **Cheshire, F. R.** 1886. *Bees and Beekeeping*, p. 66.
2. **Whitcomb, Warren, Jr. and Wilson, H. F.** 1929. Res. Bull. No. 92, Agr. Exp. Sta., Univ. of Wisconsin, Madison.
3. **Hobson, A. D.** 1928. *Brit. Jour. Exp. Biol.*, 5: 385-93.
4. **Ten Cate, J.** 1924. *Arch. Neerland. Physiol.*, 9: 598.

THE RELATIVE IMPORTANCE OF AMPHIBIANS, REPTILES, BIRDS AND MAMMALS AS HOSTS FOR CHIGGERS AND OTHER ECTOPARASITES.

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INTRODUCTORY.

Ectoparasites have long received the attention of entomologists and parasitologists and their importance economically to man, likewise, has long been recognized. Yet, notwithstanding the attention they have received, resulting in the production of a voluminous literature, we are yet in ignorance of most of the fundamental facts in regard to the relative importance of the different groups of ectoparasites upon the different major classes of vertebrate hosts. Our lack of information in this regard was most forcibly brought to the writer's attention during the early days of his investigations of chiggers. When these investigations were begun about fifteen years ago, we had no knowledge regarding the natural hosts of these minute acarids and but very little in regard to their habits. Our common chigger, *Trombicula irritans* (Riley), was supposed in nature either to feed upon insects or to suck the juices of plants. Today how different! Now we know not only that they never do these things but that they occur as normal parasites on various species of vertebrates belonging to four of the five classes.

Some may ask why it was that chiggers were so long overlooked upon their natural vertebrate hosts. It would seem that any of the ectoparasites so persistently attacking man and his domestic animals would be revealed by scientists upon some of their wild vertebrate hosts. But they were not. Doubtless the chief reason for this was because of their small size. Then again, they attach themselves directly to the skin and are largely or completely concealed by the hair or feathers of the host.

TAKING AN ECTOPARASITE CENSUS.

The demonstration of the wide occurrence of these very important parasites of man upon so many wild vertebrates was a most significant revelation of our utter lack of information in regard to the occurrence of certain ectoparasites upon the major classes of vertebrates. Hence, beginning with the summer of 1925, it was decided that a complete inventory of all arthropod parasites would be made of all amphibian and reptilian hosts that could be collected in the Central Atlantic and South Atlantic States. Three years later the same method was extended to include birds and mammals.

In taking this census of ectoparasites special methods were employed to prevent, as far as possible, their escape from their hosts before examination and also to prevent their straggling from their natural hosts to unnatural ones. Every individual parasite was taken with the exception of minute mites belonging to a few species. Each specimen was determined to species, its stage or instar recorded, and if adult its sex noted. The presence of eggs of the parasites was recorded, the nature of injury to the host and the region of the body infested, and many other items of general biological interest were put down.

Special information in regard to the host included its age (whether nestling, juvenile, breeding adult, etc.), state of health, and many other items that seemed to be of importance.

THE VALUE OF AN ECTOPARASITE CENSUS.

The information thus obtained will eventually give us a wealth of facts bearing upon many problems aside from the knowledge of the presence or absence of particular species upon a particular host. Some of these may be here enumerated. They have to do with:

1. The life history of the parasites themselves.
2. The seasonal history of the parasites.
3. The relative abundance of two or more parasitic species when occurring upon a single host species.
4. The time and method of spread of individuals of a parasitic species from one host individual to another.
5. The ecology of the scaly, feathered, or hairy environment furnished by the host.
6. The correlation, or lack of correlation, between the life history of the parasite and that of its host.

The data obtained up to the present are not sufficient for throwing much light upon some of these problems, but in regard to the relative abundance of the different major groups of ectoparasites on four of the classes of vertebrates it is believed that the data are of value. This of course does not apply to ectoparasites occurring outside of the territory under consideration or for the colder months of the year when no collections were made.

Host Group	Number of hosts examined	Species or subspecies represented	Without ectoparasites	with chiggers only	With chiggers & other ectoparasites	With ectoparasites other than chiggers	Percent infested with chiggers	Percent infested with all ectoparasites
Amphibians	462	23	352	110	0	0	23.8	23.8
Reptiles	281	30	219	46	0	16	16.4	22.1
Birds	103	37	73	10	3	17	12.6	29.1
Mammals	84	13	36	2	5	41	8.3	57.1

TABLE I. Percentages of infestation with chiggers and other ectoparasites of four classes of vertebrates. (Data for spring, summer, and fall months from Atlantic States, Maryland to Florida, inclusive.)

THE RELATIVE ABUNDANCE OF THE MAJOR ECTOPARASITIC GROUPS ON VERTEBRATES DURING THE WARMER MONTHS IN THE CENTRAL ATLANTIC AND SOUTH ATLANTIC STATES.

The results obtained for this survey are given in Table I and apply to the Atlantic States, from Maryland to Florida, inclusive. Records were obtained for the spring, summer, and fall months and largely from the States of Maryland, Virginia, and North Carolina. No records were obtained from the mountainous regions in the western part of these States.

The outstanding fact revealed in this census is the important role played by amphibians as hosts for ectoparasites. Of the 462 individuals obtained, representing 23 species, no less than 110, or 23.8 per cent, were parasitized. When this census

was begun ectoparasitism of amphibians, except for occasional records of attacks by ticks, was practically unknown. It revealed, however, that amphibians are heavily infested with mites, and are in fact more heavily infested than are reptiles.

According to this survey, mammals are the most heavily parasitized with arthropods of any of the four classes of vertebrates considered. Over 57 per cent of the mammals were found infested.

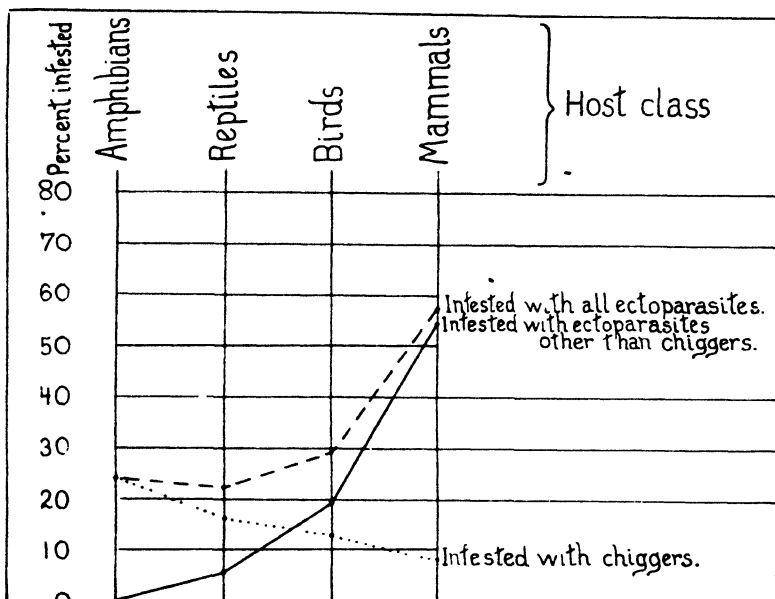


CHART I. Plot showing percentages of infestation with chiggers and other ectoparasites of hosts belonging to four classes of vertebrates.

The figures indicating the percentage of individuals infested with chiggers are of much practical importance from the standpoint of their control. Amphibians proved to be the most heavily parasitized with these mites, the percentage of individuals having them being 23.8. Reptiles came next with a percentage of 16.4, then the birds with a percentage of 12.6, while mammals were the least infested, the percentage being 8.3. In this paper no attempt shall be made to go into the details of the census taken. It might be well here to state, however, that young toads and frogs account for most of the percentage

figure for the amphibians; our common box-turtle, *Terrapene carolina*, for the reptiles; and ground-frequenting birds, for the figure for this class.

The relative abundance of chiggers and all other ectoparasites on amphibians, reptiles, birds, and mammals, as indicated by the number of individuals infested, is shown in the form of a diagram (Chart 1). This diagram indicates clearly how relatively unimportant the mammals are as hosts for chiggers, and also how this class far surpasses the other three in importance in furnishing hosts for ectoparasites other than chiggers.

SUMMARY.

1. A preliminary report is given of what is believed to be the first census ever to be taken of the ectoparasites of four of our five classes of vertebrates, the amphibians, the reptiles, the birds, and the mammals.

2. This report is of a very general nature, and has to do primarily with the relative abundance of ectoparasites upon these four classes of vertebrates during the spring, summer, and fall months of the year in the Atlantic States from Maryland to Florida, inclusive.

3. Amphibians are shown for the first time to be hosts of major importance as far as the mites are concerned.

4. The relatively unimportant part played by mammals as hosts for chiggers in this section of the country is indicated.

BOOK NOTICE.

COMMON PESTS, by RENNIE W. DOANE, pp. I-VIII, 1-384 and index (13 pp.); 215 illustrations, 1931. Charles C. Thomas, publisher.

We call attention to this well written volume because it is largely entomological and because it is a well thought out effort in non-technical language to convey correct scientific information concerning pests to the lay reader. It has recently been said that scientific research is already fifty years ahead of the spread of this same knowledge among the people. This lack of understanding of science, of what it is all about, is particularly serious among legislators who now hold so many purse strings on research. Any effort of science to bridge this gap is very welcome. Professor Doane has given us a well illustrated book of this type which covers not only common insect pests but has chapters on near relatives of insects, parasitic worms, mammals and birds. The illustrations are largely from remarkably good photographs.

—C. H. K.

A METHOD OF MEASURING TRACHEAL VENTILATION IN INSECTS AND SOME RESULTS OBTAINED WITH GRASSHOPPERS.

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This method of measuring the amount of tracheal ventilation produced by the respiratory movements of some insects consists of enclosing the head and thorax of an insect in one chamber and the abdomen in an adjoining chamber. The insect is sealed into the tube that connects the two chambers. The air forced from one chamber into the other through the tracheal system of the insect is then measured.

Lee² (1925) demonstrated that air passed into the thorax and out of the abdomen of certain Orthoptera. The method described in this paper is a quantitative method of measuring the passage of air through the tracheal system of the insect. The method is given in detail here as it is believed that it will be useful to those interested in the study of respiration in insects. The method is adapted to the study of the effect of various gases on the rate and amount of air movement into and out of the tracheal system. It may also be used to study the effect on the insect of passing various gases through the tracheal system and also to study the gain or loss of the constituents in a gas mixture after it has passed through the tracheal system.

APPARATUS.

The apparatus as shown in Figure 1 consists of two closed chambers, *A* and *B*, which are connected by a tube *y*, into which the insect is sealed so that any air passing from one chamber to the other must pass through the tracheal system of the insect. The horizontal capillary glass tubes, *A'* and *B'*, attached to each chamber are each closed by a column of water about 2 to 3 cm. long. These columns of water are free to

¹A contribution from the Department of Zoology and Entomology, Iowa State College, Ames, Iowa.

²Lee, M. O. (1925) Jour. Exp. Zool., Vol. 41, pp. 125-154.

move in either direction in the tubes. Metric rulers are attached to capillaries *A'* and *B'* to facilitate the measurement of the movement of the water columns. By the use of a manometer it was determined that if the capillary tubes used are about 30 cm. long, clean and moist and the water column near the center, an increase or decrease of one ten-thousandth

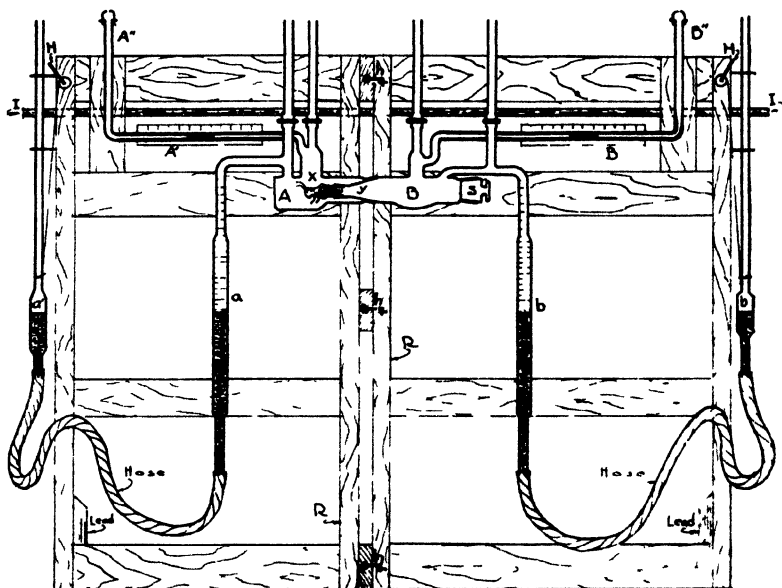


FIG. 1. An Apparatus for Measuring Tracheal Ventilation in Insects.

A.—A chamber that encloses the head and thorax of the insect. *B*.—A chamber that encloses the abdomen of the insect. *A'* and *B'*.—Capillary tubes closed by water columns. *A''* and *B''*.—Rubber bulbs. *a* and *b*.—25 cc pipettes. *a'* and *b'*.—Adjustable reservoirs connected with pipettes *a* and *b*. *S*.—A ground glass stopper. *H*.—Handles used to adjust reservoirs *a'* and *b'*. *R*.—The two parts of the wooden rack the apparatus is mounted on. *I*.—An iron rod. *h*.—Hooks that hold the two parts of the rack together. *y*.—A tube that opens into chambers *A* and *B*. *x*.—A short piece of tube with the insect sealed inside it with beeswax and the tube, itself, sealed inside the tube *y* with vaseline.

(1–10,000) of an atmosphere in the pressure within the chamber will initiate a slow movement of the water column in the capillary. Rapid movements such as often occur during the most active respiratory movements of a grasshopper require a change in pressure of about one five-thousandth (1–5,000) of an atmosphere. With a capillary tube of between 1 and 2 mm. bore a change in the volume of the contents of either side of

the apparatus of 1 cubic millimeter can be observed. Further, it is possible with this method to maintain the air pressure in each of the two chambers in contact with the insect to within one ten-thousandth of the pressure of the surrounding atmosphere during any changes in volume of air in either or both chambers within the limit of the capacity of the moist portion of the capillary tube and the volume of the pipette, *a* or *b*, attached to the chamber. Each of these pipettes is connected by a rubber tube to a reservoir, *a'* or *b'*, containing water. These reservoirs open to the atmosphere by a long glass tube and are held in place by screw eyes driven into the side of the rack as shown in the figure. They can be raised or lowered by turning the handles, *H*. If the handle connected to pipette *a* by a cord is turned so that the reservoir *a'* is raised the water will flow from it into pipette *a* through the rubber tube connecting them. In this manner the total volume of air the *A* side of the apparatus can contain is decreased. If the reservoir is lowered the water will flow into it from pipette *a* and the volume of air that the *A* side of the apparatus can contain is increased. By repeated adjustment of the water level in pipette *a* so that the water column is kept about the center of the capillary tube *A'* a large change in volume in chamber *A* can be permitted without an increase or decrease in the pressure in the chamber of more than one-ten-thousandth of an atmosphere. The same procedure can be followed with the *B* side of the apparatus. By the selection of a suitable pipette a test of any duration can be obtained; however, it is desirable to use a pipette of a diameter as small as possible as this permits more accurate readings.

A short piece of glass tube, *x*, about 5 or 6 cm. long that will just slip inside the tube, *y*, on the part of chamber *B* that extends into chamber *A* is used in sealing the insect into the passage between the chambers. One end of this tube, *x*, is heated and shaped so that it will fit fairly snugly (within about 1 mm. on all sides) the body of the insect at the juncture of the thorax and abdomen. The tube once properly shaped may be used repeatedly for insects of the same size and shape.

Each chamber is provided with two glass stop-cocks which may be used to introduce gases or liquids into the chambers or to make the initial adjustment of the volume of air at the beginning of a test.

The rack *R* upon which the apparatus is mounted consists of 2 wooden frames held together by an iron rod *I* and three hooks *h*. The iron rod *I* is slipped through both parts of the rack allowing them to be moved separately so that after an insect is placed in tube *y* the two sides of the rack with the apparatus attached can be moved together to close chamber *A*. Chamber *A* is closed by a ground glass joint where it slips over the end of chamber *B* just back of tube *y*. Chamber *B* is closed by a ground glass stopper *S*. The rod *I* is used to suspend the apparatus in a water bath. The apparatus is held in place on the rack by heavy rubber bands. A rubber band is used to hold chambers *A* and *B* together and stopper *S* in place.

The small rubber bulbs *A''* and *B''* are used to adjust the water columns in the capillaries to the desired positions at the beginning of a test.

PROCEDURE.

Grasshoppers, chiefly adult female *Chortophaga viridifasciata* DeG., were used as experimental specimens. It was found that if the wings were removed as close to the thorax as possible a day or two before the test a much more satisfactory seal could be made. The abdomen of such an insect was then thrust into the tube *x* until the bases of the hind legs touched the end of the tube. The end of the tube that had been shaped to fit the insect's body was in this manner brought to encircle the insect at the juncture of the thorax and abdomen. The insect was sealed to the end of the tube by applying small drops of melted beeswax (about 2 milligrams in a drop) to the edge of the tube and allowing them to come in contact with the integument of the insect as they solidified. The insect was held securely in the end of the tube during this operation. In this manner the posterior edge of the thorax and part of the anterior edge of the abdomen were sealed to the end of the glass tube *x*. The wax usually closed the tympanic spiracles. The tube with an insect sealed in the end was then filled with water and held with the insect downward to detect any leaks. If the seal was perfect, the water was removed from the tube and the insect allowed to remain quiet for, at least, 45 minutes. This permitted the initial excitement of being confined in the tube to wear off. The short piece of tube *x* was then sealed with

vaseline inside the tube *y*. Chamber *A* was closed by moving the two parts of the apparatus together until an air-tight seal was formed by the ground glass joint between chambers *A* and *B*.

The success of the test depended upon the insect being sealed perfectly into the tube that connected *A* and *B*. To test the seal the stop-cocks were closed on both the chambers and the pressure increased slightly in *A*. The pressure in either chamber may be increased by raising the level of the water in the pipette connected with it or decreased by lowering the level of water in the pipette. If an increase in the pressure in *A* produced equal movements of the water columns in both capillaries *A'* and *B'* air was leaking from *A* into *B* outside the tracheal system of the insect. If the water column in capillary *A'* moved away from the chamber, but the one in capillary *B'* remained almost stationary the seal was perfect. A further check was made by increasing and decreasing the pressure in *B* by changing the water level in pipette *b* and observing the results. Care was taken not to apply too much pressure to *A* or *B* as this would have blown the water column out of the capillary tube.

When a perfect seal was obtained the entire apparatus mounted on the rack was immersed in a water bath and allowed to remain for five minutes to assume the temperature of the bath. The water columns in the capillaries *A'* and *B'* and the level of the water in pipettes *a* and *b* were then adjusted to the desired positions with the stop-cocks on both chambers open. After closing all the stop-cocks the readings on the capillaries and pipettes were recorded and the test started. The closure of the stop-cocks enclosed a definite volume of air within the apparatus. This air could be moved from one chamber to the other by the respiratory movements of the insect but the total volume of air in the apparatus remained constant unless more or less oxygen was used by the insect than the amount of carbon dioxide given off, or changes in atmospheric pressure occurred during the test. As the grasshopper breathed the water column in capillary *A'* was observed to move toward chamber *A* and the water column in capillary *B'* was observed to move away from chamber *B*. When the water column approached the end of capillary *A'* the water level in pipette *a* was raised. This procedure forced some of the air out of pipette *a* into chamber *A* and capillary *A'* moving

the water column away from the chamber. This operation was repeated each time the insect withdrew sufficient air from chamber *A* so that the water column approached the end of capillary *A'* nearest chamber *A*. As the other water column approached the end of capillary *B'* farthest from chamber *B* the water level in pipette *b* was lowered. This procedure drew air into the pipette from chamber *B* and capillary *B'* so that the water column was moved toward the end of the capillary nearest chamber *B*. As soon as the insect had forced sufficient air into chamber *B* so that the water column approached the opposite end of the capillary the operation was repeated. In this manner it was possible to observe small changes (from 1 to 400 cubic millimeters) in the volume of air in either chamber by noting the movements of the water columns in the capillaries. The total volume change (up to 25 c.c.) in either chamber could be calculated from the difference between the water levels in the pipettes and the difference between the positions of the water columns in the capillary tubes from the beginning to the end of the test.

If the apparatus had not been in operation for 30 minutes or longer before a test was started it was found advisable to moisten the walls of capillaries *A'* and *B'* by moving the water columns back and forth across the tube three or four times. The rubber bulbs *A''* and *B''* were used for this purpose. In the upper end of each bulb a small hole that could be readily closed with a finger allowed air to be either forced into or drawn out of the capillary. In this manner the water columns could be easily moved back and forth in the tube and adjusted to any desired position. During a test the holes in the bulbs permitted the maintenance of atmospheric pressure within the capillaries. By clamping the walls of the rubber bulbs firmly together with a screw clamp it was possible to prevent the water columns from being forced out of the capillaries ^{when} the apparatus was moved or tipped.

In some tests a standard solution of $\text{Ba}(\text{OH})_2$ was placed in each chamber to absorb the CO_2 evolved by the insect. The excess $\text{Ba}(\text{OH})_2$ that remained at the end of the test was titrated through one of the stop-cocks with a standard solution of HCl . Phenolphthalein was used as the indicator.

Chambers *A* and *B* were rinsed with distilled water at the beginning of each test. The water was allowed to stand in

the chambers for a short time to allow the air in the chambers to become nearly saturated with water vapor.

RESULTS.

By this method it was found in all but one instance that the air was inhaled principally into the thorax and exhaled principally from the abdomen. In this one instance, *one* of 25 adult female grasshoppers, *Dissosteira carolina* Linn, exhibited very abnormal respiratory movements. The prothorax was extended and the head "nodded" rhythmically in a gasping manner. Air was inhaled principally into the abdomen and exhaled principally from the thorax. It exhibited a reversal of the usual direction of air movement through the tracheal system. Collodion was used to seal the *D. carolina* to the glass tube in the apparatus. The movement of air into the thorax and out of the abdomen in all but this one of the *D. carolina* and in all of the *C. viridifasciata* was pulsatory and periods of inactivity that lasted for as long as two minutes at 28 degrees Centigrade occurred at intervals. Frequently at the end of the rapid movement of the water column there would be a brief reversal in the direction of movement which was more noticeable on the side that enclosed the abdomen.

The results of the measurements of the total amount of air passing through the tracheal system of grasshoppers are given in Tables I and II.

As an approximate check on the rate of air passage through the tracheal system of adult female *C. viridifasciata* the movement of the water columns in the capillary tubes was timed with a stop-watch. Although the rate of movements was extremely variable it was found that 0.025 c.c. of air passed through the tracheal system in about 9 seconds, average time per gram of insect, with a minimum of 2 seconds and a maximum of 45 seconds. As the volume change and duration in each of these observations was very small the results were quite variable.

The average amount of air inhaled into the thorax at 28 degrees Centigrade at a single inhalation by adult female *C. viridifasciata* was 0.006 c.c. based on 116 observations. The maximum amount inhaled at a single inhalation was 0.015 c.c. An average of 0.006 c.c. of air was exhaled from the abdomen at a single exhalation by these insects. The maximum amount of air exhaled at a single exhalation was 0.011 c.c.

TABLE I.

Tracheal Ventilation of *Chortophaga viridifasciata* DeG. at 28° C.
Adult Females.

Test No.	Barometric Pressure in mm. of Hg.	Duration of Test in Minutes	Total Amount of Tracheal Ventilation in c. c.	Tracheal Ventilation per Minute per Gram of Insect in c. c.
1	738.6	25	2.977	0.173
2	737.7	25	3.614	0.210
3	743.1	33	4.153	0.187
4	748.9	40	4.021	0.187
5	749.2	40	3.980	0.184
6	743.0	30	3.948	0.225
7	738.0	42	5.083	0.196
8	737.2	36	5.020	0.226
9	737.2	41	5.084	0.201
10	737.7	39	2.858	0.167
11	737.7	28	2.160	0.176
12	737.7	27	1.889	0.160
13	740.2	19	2.904	0.233
14	740.2	20	3.076	0.235
15	740.2	21	3.064	0.217
16	743.5	25	4.865	0.272
17	743.6	9	1.974	0.306
18	743.6	15	3.036	0.283
19	743.6	21	2.950	0.242
20	743.6	20	3.163	0.275
21	743.6	30	4.282	0.249
22	743.6	17	3.026	0.262
23	743.5	20	3.961	0.291
24	743.5	14	3.158	0.331
25	743.4	24	4.904	0.300
26	743.4	20	2.861	0.261
27	743.3	20	2.872	0.262
28	743.2	28	4.035	0.262
29	738.8	31	4.002	0.199
30	738.7	26	3.996	0.238
31	738.7	33	5.048	0.234
32	736.0	26	3.850	0.202
33	736.0	19	3.083	0.221
34	735.5	19	2.763	0.198
35	734.4	42	3.775	0.123
36	734.0	30	3.177	0.147
37	733.9	28	2.932	0.143
38	733.3	26	2.962	0.174
39	733.1	22	3.156	0.218
40	737.3	22	3.011	0.196
41	737.3	19	3.113	0.234
Average.....		.....	.....	0.222 ± 0.043*

*Standard deviation formula = $\sqrt{\frac{\sum d^2}{n-1}}$

When a standard solution of $\text{Ba}(\text{OH})_2$ was placed in each chamber during 16 tests at 23 degrees Centigrade it was found that adult female *C. viridifasciata* exhaled an average of about 20% of the CO_2 evolved from the thorax and 80% from the abdomen.

The confinement of the insects in the manner described did not seem to injure them. All the specimens studied lived a week or longer after they were released. One grasshopper which was sealed in the tube for 24 hours fed immediately after it was released. Grasshoppers that have been used as experimental animals have been observed to lay eggs which later hatched.

TABLE II.

Tracheal Ventilation of *Chortophaga viridifasciata* DeG. at 23° C.
Adult Females.

Test No.	Barometric Pressure in mm. of Hg.	Duration of Test in Minutes	Total Amount of Tracheal Ventilation in c. c.	Tracheal Ventilation per Minute per Gram of Insect in c. c.
1	747.2	63	1.554	0.055
2	747.1	65	1.468	0.050
3	733.8	61	7.168	0.166
4	733.2	79	6.330	0.113
5	742.0	67	5.942	0.146
6	742.2	67	6.085	0.147
7	745.0	30	2.023	0.107
8	745.0	50	3.041	0.095
9	744.2	35	3.008	0.135
10	743.6	44	2.010	0.086
11	743.4	65	2.612	0.074
Average.....				0.107 ± 0.039

SUMMARY.

A method is described that can be used to measure the tracheal ventilation of some grasshoppers.

The respiratory movements of grasshoppers, *C. viridifasciata*, produced a pulsatory streaming movement of air through the tracheal system. The air was inhaled principally into the thorax and exhaled principally from the abdomen.

Adult female *C. viridifasciata* at 28 degrees Centigrade passed an average of 0.222 c.c. of air through their tracheal system per minute per gram of body weight with a minimum of

0.123 c.c. and a maximum of 0.331 c.c. At 23 degrees Centigrade similar insects passed through their tracheal system an average of 0.107 c.c. of air per minute per gram with a minimum of 0.050 c.c. and a maximum of 0.166 c.c.

Adult female *C. viridifasciata* exhale an average of 20% of the total CO₂ evolved from the thorax and 80% from the abdomen of 23 degrees Centigrade. If it can be assumed that all the exhaled air contains the same percentage of CO₂, it is evident that only part (about 80%) of the air movement within the tracheal system of these insects is a through movement in the direction given above.

ACKNOWLEDGMENTS.

The author takes this opportunity to thank Dr. C. H. Richardson under whose direction this study has been carried on for the many helpful suggestions he has made. The author also wishes to thank the other members of the Faculty of the Department of Zoology and Entomology of Iowa State College for the assistance they have given in carrying on this research.

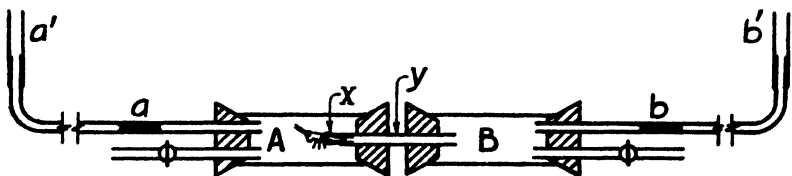


FIG. 7. A Simplified Apparatus to Demonstrate Tracheal Ventilation in Insects.

A.—A chamber to enclose the head and thorax of the insect. B.—A chamber to enclose the abdomen of the insect. a and b.—Capillary tubes closed by water columns. a' and b'.—Short pieces of soft rubber tube used to adjust the water columns in a and b to the desired position. y.—A tube connecting chambers A and B. x.—A short piece of tube that the insect is sealed into and that fits inside tube y.

APPENDIX.

At the suggestion of Dr. J. F. Yeager that a simplified apparatus of this type might be useful to demonstrate tracheal ventilation to classes in insect physiology the following apparatus was constructed.

This apparatus may be constructed from ordinary glass tubing, rubber stoppers, and thin-walled rubber tubing. Capillaries of 1–2 mm. bore have been found satisfactory for a and b.

The sizes of the tubes to form chambers *A* and *B* and tubes *x* and *y* will depend upon the size of the insect that is studied.

The operation of the apparatus is similar to that given for the apparatus shown in Figure 1. The insect is sealed into the tube *x* with beeswax. Tube *x* is sealed inside tube *y* with vaseline with the head and thorax of the grasshopper in chamber *A*. The apparatus is then assembled as shown in Figure 2. Rubber bands may be used to hold the stoppers in place. The water columns in *a* and *b* are adjusted to about the center of the moist portion of the horizontal parts of capillaries *a* and *b*. The stop-cocks are closed and the movement of the water columns in the capillaries observed.

The seal of the insect into tube *y* may be tested by increasing the pressure in chamber *A* or *B*.

The volume change that can be observed will be limited to the volume of the moist portions of the capillary tubes.

ON THE LENGTH OF THE ADULT LIFE IN THE WEBBING CLOTHES MOTH, *TINEOLA* *BISSELLIELLA HUM.*

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Cornell University.

Although the webbing clothes moth (*Tineola bisselliella* Hum.) is a common pest in many parts of the world, few investigators seem to have been interested in the bionomics of this insect. The observations to be discussed in the present paper have been made in connection with an extensive study which is under way concerning the food habits of clothes-moth larvæ. The insects are being reared from the egg stage. As soon as the eggs hatch, each larva is placed in a small shell vial with its particular kind of food. The vials are kept in a dark cupboard under temperature and humidity conditions comparable to those of an ordinary living room. While the larvæ are small, the vials are examined from time to time as opportunity offers. When the larvæ become nearly full grown,

however, daily observations are made, as it is desired to know the exact length of the life cycle in every instance. Knowing the date of emergence, it seemed worth while to carry the observations further and to determine the length of the adult life for each individual reared.

The sexes in *Tineola bisselliella* are not easily distinguished. There appear to be no secondary sexual characters which can be relied upon. Sometimes the genitalia protrude, but often they do not. It therefore seemed advisable to cut off the end of the abdomen in each instance and to boil it, first in distilled water, and then, for another minute, in caustic potash. This procedure clears the genitalia perfectly, so that the sex of each particular specimen can be accurately determined. Of course each specimen has to be boiled separately, since each has its own special experiment number.

This paper has to do with 143 males and 171 females which have emerged in individual vials since July 12, 1930. The food in all these cases has been fur. Since the present nutrition studies were begun, a total of 531 adults have emerged, including those reared on fur. Of these 260 were males, and 271 were females. Titschack (1926:334) reared a total of 631 adults, of which 311 were males, and 320 were females. From his observations and from those already made at the Cornell Insectary, it appears that the sexes in *Tineola bisselliella* are about evenly divided. •

When the length of the adult life is considered, however, there is a marked difference between the sexes. In the present study, the males have been found to live nearly twice as long as the females. For the 143 males observed, the minimum length of adult life was 13 days, the maximum 79 days, and the average 41.755 days. For the females, the minimum was 10 days, the maximum 48 days, and the average 21.818 days. Titschack's data for the females are similar to those just given, but his average for the adult life of the males is different, and is not much larger than that for the females. He found, however, that fertilized females do not live as long as do unfertilized ones. None of the adults reared so far at Cornell have been permitted to mate, so no figures are yet available for the length of the adult life of fertilized females.

For the purpose of bringing out clearly the differences between the length of the adult life of the males and that of

the females, curves have been plotted.* In order to plot these curves, it was necessary to group the insects into classes with respect to the number of days of adult life—for example, those living for 10 to 14 days, for 15 to 19 days, for 20 to 24 days, and so on—and the frequency values had to be changed into percentages. Based on this arrangement of data, the mean in the males was found to be 41.790 days, with a probable error of $\pm .676$, while the mean in the females was found to

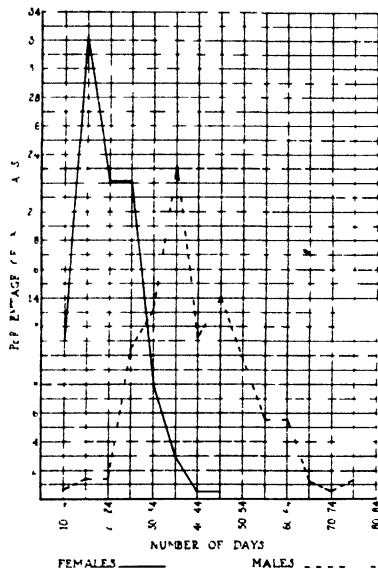


CHART I. Length of adult life in the webbing clothes moth (*Tineola bisselliella* Hum.): a comparison of the length of adult life in the male with that in the female. The curves are based on data obtained from the adult life of 143 males and 171 females

be 21.912 days, with a probable error of $\pm .348$. The difference between the two means is 19.878, while the probable error of that difference is $\pm .760$. When the difference between two means is four or more times the probable error of that difference, the difference is considered statistically significant. With the data represented by the curves, the difference between the two

*The author wishes to acknowledge her indebtedness to Professors H. H. Love and J. R. Livermore, of the Department of Plant Breeding at Cornell University, for advice and assistance in connection with the statistical phases of the problem.

means is over twenty-six times the probable error of that difference. The data at hand, therefore, seem to have conclusively proved that the length of the adult life of the males is much longer than is that of the females.

The adult of *Tineola bisselliella* is commonly said to have poorly developed or degenerate mouth parts. Titschack (1922:15) gives a figure in which he shows that the proboscis is lacking, although the labial palpi are prominent, as in most Lepidoptera. But even if the adult possessed a well developed proboscis, what liquid food could it find in a small vial containing nothing but a piece of dry fur? It therefore appears that the webbing clothes moth must consume enough food during its larval stage to carry it through, not only the pupal stage, but through an adult life which averages nearly six weeks for the males and about three weeks for the females.

As more data become available, it will be interesting to determine whether there is any correlation between the kind of food on which the larva has been reared and the length of the adult life.

REFERENCES CITED.

- Titschack, E. Ztschr. f. techn. Biol. 10: 1-168. 1922.
Verh. naturhist. Ver. preuss. Rheinl. u. Westf. 82 (1925): 330-348.
1926.

BOOK NOTICE.

ANIMAL ECOLOGY WITH ESPECIAL REFERENCE TO INSECTS, by ROYAL N. CHAPMAN, pp. I-X, —464, including an appendix of 40 pages by Volterra; 137 graphs and other illustrations. McGraw-Hill Book Company. Inc., New York and London.

As all economic entomology is basically applied ecology, this is a volume that should be in the hands of every economic entomologist. As it is the latest presentation of the principles of the science it will be the class and textbook for students. It has special significance in its field of thought because in it are fully outlined for the first time Chapman's own contributions, the principles of biotic potential and environmental resistance. As the volume deals with principles it is largely on the field of autecology. Our great lack of a knowledge of synecology is shown by the 113 pages given to aquatic ecology as against 45 pages devoted to the ecology of land forms, yet the great variety of life is on land, certainly much over 75 per cent of all living forms and with insects an even higher percentage, as insects rarely invade the sea. Land ecology (terrestrial synecology) is almost an unexplored field. Work on land forms will long remain largely in the field of qualitative ecology as against the more ideal quantitative ecology as presented in this admirable volume. The book is a landmark in entomology, American or otherwise, and substantiates the outstanding position of Professor Chapman in entomology.

—C. H. K.

NEW WEST INDIAN DIPLOPTERA.

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The following descriptions of new species and varieties of West Indian Vespidae have been in manuscript for some time. It was our intention to include them in a revision of the Diploptera of the Antilles, which, however, may not be published in the near future. Since types and paratypes of these new forms have been distributed in various collections,³ it seems advisable to publish the descriptions without further delay. The affinities of these forms will be discussed in the final paper, where we also hope to figure the structural characters of the several species.

Zethus bahamensis, new species.

Medium-sized, moderately slender. Black, with the legs, antennae, and base of first and second abdominal segments partly red, and with very few yellow markings.

Length (h. + th. + t. 1 + 2): ♀, 13 mm.

Female.—Head, seen from above, more transverse than in *Z. poeyi* H. de Saussure, being over twice as wide as long and considerably broader than the thorax, the posterior margin much more deeply emarginate than in *Z. poeyi*. Vertex and cheeks margined throughout by a carina, which is rather low and blunt on the vertex and the lower

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³NOTE. The following abbreviations have been used throughout for the location of the types:

A. M. N. H.—American Museum of Natural History.

A. N. S. Phila.—Academy of Natural Sciences of Philadelphia.

B. M.—British Museum.

C. M.—Carnegie Museum, Pittsburgh.

Corn. Univ.—Dept. of Entomology of Cornell University.

Est. Agr. C.—Estacion Exp. Agronomica de Cuba.

M. C. Z.—Museum of Comparative Zoology, Cambridge, Mass.

N. Y. Ac. Sci.—New York Academy of Sciences Survey (deposited at the American Museum of Natural History).

U. S. N. M.—United States National Museum.

half of the cheeks, but becomes very high and sharp on the upper half of the cheeks where it forms (as seen from above) a sharp angle; about the middle of the cheeks, where the carina becomes lower, it sends off a branch on the under side of the head separating the postgenae from the occiput, the point of junction (seen in profile) being not in the least projecting. Cheeks well developed, somewhat more swollen behind the eyes than in *Z. poeyi*; in profile a little narrower than the widest part of the eye. Oculo-malar space absent. Inner orbits a little farther apart on the vertex than at the clypeus. Ocelli placed as in *Z. poeyi*, but relatively nearer the occipital margin. Interocellar area only slightly depressed in the middle, not appreciably ridged on the sides near the posterior ocelli. Antennae twice as far apart as from the inner orbits; the space between them much more raised than in *Z. poeyi*, the upper part forming a transverse ridge much flattened and smooth in the middle where it connects with a low, blunt, interantennal carina; no longitudinal depression below the anterior ocellus, but the raised frons (above the insertion of the antennae) with a median fovea. Clypeus much as in *Z. poeyi*, but the apical truncation slightly narrower, with very blunt edges, and the slight median projection not tuberculate. Eyes bare. Antennae and mandibles as in *Z. poeyi*. Thorax, seen from above, broadly elliptical, distinctly more stubby than in *Z. poeyi*, one and one-half times as long as wide, broadly truncate posteriorly and anteriorly; in profile one and one-third times as long as high. Pronotum short, much wider and more convex on the sides (as seen from above) than in *Z. poeyi*; anterior margin very slightly concave, with a strong, opaque, raised lamella which is only slightly higher in the middle and continues downward to within a short distance of the front coxae; humeral angles rounded, but more prominent than in *Z. poeyi*; a lateral carina in front of the posterior lobe, as in that species. Mesonotum with three longitudinal impressed lines, as in *Z. poeyi*, but the traces of notauli less distinct than in that species owing to the coarser sculpture. Scutellum much more raised than in *Z. poeyi* and with a deep, narrow, median, longitudinal groove, separated from the mesonotum by a very narrow groove which is not foveolate. Postscutellum transverse, without carinae, ridges, longitudinal grooves or teeth, uniformly convex, but more swollen than in *Z. poeyi*. Mesopleura as in *Z. poeyi*. Propodeum very short; with an almost vertical concavity, which is very shallow, bears a median impressed line but no carina, and is not striate; superior and inferior ridges broadly rounded; lateral ridges with a sharp but low carina; lateral angles broadly rounded. First abdominal segment about as long as the thorax, but shorter than the second segment; shaped almost exactly as in *Z. poeyi*, although a little broader toward the apex; greatest width at about the middle of the length and about one and one-half times the width at the apex; basal stalk much as in *Z. poeyi*, with a sharp transverse carina behind the extensory muscle, but without the longitudinal ridges of that species; preapical, transverse depression hardly marked and forming no basin in the middle. Second segment bell-shaped, in outline intermediate between that of *Z. poeyi* and that of *Z. cubensis* Zavattari, being rather

gradually narrowed into a slender neck which is about one and one-half times as long as the width of the basal articulation; swollen portion, seen from above, about as wide as long, and, in profile, slightly longer than high, moderately and equally swollen above and below; apical margin duplicate, the terminal lamella flat, not expanded on the sides, and not translucent. Apical margins of succeeding segments simple, not duplicate. Legs as in *Z. poeyi*; middle tibiae with a single, long, apical spur; middle and hind tibiae with the usual apical comb of heavy spines. Wing venation much as in *Z. poeyi*; third cubital cell much shorter than the second on the cubitus and distinctly higher than wide.

Puncturation very coarse and dense on head and thorax; vertex, frons, pronotum, mesonotum and mesopleura almost rugoso-reticulate; the rugosities having a tendency to form longitudinal striae on the frons; the punctures smaller and more scattered in the upper third and in the center of the clypeus. Propodeum almost impunctate, except for a few, very scattered, medium-sized punctures on the dorsal areas, which in addition bear in their posterior half a few irregular, transverse striae. Anterior part of mesopleura (in front of the epicnemial carina), their extreme posterior edge, and metapleura impunctate; upper half of metapleura with about eight transverse striae which are much more pronounced than in *Z. poeyi*. Tegulae with a few scattered, medium-sized punctures. First abdominal tergite with scattered, medium-sized punctures which are distinctly larger and more numerous than in *Z. poeyi*; second tergite practically impunctate, the few punctures being visible only under a high magnification. On the second sternite the punctures are numerous, rather scattered, and medium-sized, being about as large as those of the first tergite. Succeeding segments sparsely covered with rather small punctures. Abdomen more shiny than head and thorax, which are uniformly dull. Pubescence very short and sparse grayish, somewhat longer and more abundant on the sides of the clypeus, in the antennal pits, on the sides of the thorax, on the propodeum, on the legs, and on the under side and at the base of the first abdominal segment.

Black. Under side of the first three and the last antennal segments, legs (except most of the coxae), tegulae, and stalk-like bases of the first and second abdominal segments, reddish brown (Ridgway's burnt sienna); hind margin of pronotum very narrowly reddish in its posterior half. The only sulphur-yellow markings (Ridgway's light cadmium) in the type and paratype are a small, transverse spot on each side of the frons above the insertions of the antennae, a moderately wide and somewhat wavy, pre-apical fascia on the first tergite (much produced anteriorly and broadly rounded on the sides), and traces of a narrow pre-apical fascia on the sides of the second tergite. Wings infusate, purplish brown, somewhat ferruginous toward the base; stigma and veins black; costa and veins near the base ferruginous.

BAHAMAS. Nassau, New Providence, two females (G. P. Engelhardt); holotype in M. C. Z.

***Eumenes (Delta) confusus*, new species.**

- Eumenes abdominalis* H. de Saussure, 1852, 'Et. Fam. Vesp.', I, p. 70 (♀). H. Lucas, 1856, in de la Sagra, 'Historia Fis. Pol. Nat. Cuba,' Segunda Parte, Hist. Nat., VII, p. 321 (♀); 1857, in de la Sagra, 'Histoire Phys. Pol. Nat. Cuba,' VII, p. 768 (♀). F. Smith, 1857, 'Cat. Hym. Brit. Mus.,' V, p. 32. Cresson, 1865, Proc. Ent. Soc. Philadelphia, IV, p. 157 (♀♂). Stahl, 1882, Fauna de Puerto-Rico, p. 201. Gundlach, 1886, 'Contrib. Ent. Cubana,' II, p. 145. Not *Sphex abdominalis* Drury, 1773.
- Eumenes (Zeta) abdominalis* H. de Saussure, 1875, Smithson. Miscell. Coll., XIV, No. 254, p. 106 (♀♂). Zavattari, 1912, Arch. f. Naturgesch., LXXVIII, Abt. A, Heft 4, p. 125 (♀).
- Eumenes colona* H. Lucas, 1856, in de la Sagra, 'Historia Fis. Pol. Nat. Cuba,' Segunda Parte, Hist. Nat., VII, p. 321 (♀); 1857, in de la Sagra, 'Histoire Phys. Pol. Nat. Cuba,' VII, p. 767 (♀); Atlas, Pl. XIX, fig. 1 (♀). Ashmead, 1900, Trans. Ent. Soc. London, p. 312 (in part). Not *E. colona* H. de Saussure, 1852.

The common, large Cuban species of *Eumenes* appears to be without a valid name. Following de Saussure's example, it has thus far been generally called "*E. abdominalis*," in the belief that it was identical with *Sphex abdominalis* Drury. But Drury's species was from Jamaica and, moreover, his description (especially of the color of the first abdominal segment) does not fit the Cuban wasp. *Eumenes colona* H. de Saussure, likewise, was based upon a wasp from Jamaica which we regard as identical with *Sphex abdominalis* Drury, so that the name *colona* also is not available for the Cuban species.

The typical color form of *E. confusus*, of Cuba, may be described as follows:

A large species. Mostly red, with a few black and numerous sulphur yellow markings on head, thorax and first abdominal segment.

Length (h. + th. + t. 1 + 2) : ♀, 17 to 18 mm.; ♂, 16 to 16.5 mm.

Female.—Head, seen in front, about one and one-third times as wide as high; seen from above, transverse, about two and one-half times as wide as long, about as wide as the thorax. Vertex and cheeks margined throughout by a sharp carina, which on the vertex is moderately below the level of the ocelli. Cheeks very narrow, in profile not much wider in their upper half than below. Oculo-malar space absent. Inner orbits but little farther apart on the vertex than at the clypeus. Ocelli in a flattened triangle; the posterior pair a little farther apart than from the eyes; the anterior ocellus only a little larger than the posterior ocelli. Interocellar area flat; vertex without fovea. Antennae, twice as far apart as from the inner orbits; frons between them raised longitudinally; the ridge meeting an obtuse, transverse crest above the middle of the interantennal area, the point of junction forming a truncate tubercle; above the tubercle a fine carina runs to about midway from

the anterior ocellus. Clypeus about one and one-quarter times as long as wide, almost regularly octagonal, moderately and uniformly convex over the entire surface; the anterior, free portion about three-quarters the length of the upper, interocular part; the apical margin more than one-third of the total width of the clypeus, shallowly, arcuately emarginate, with very broadly rounded edges. Eyes bare. Antenna elongate; flagellum rather distinctly but moderately swollen in its terminal half; scape less than one-third the length of the flagellum; third antennal segment about twice as long as the fourth; fourth to sixth distinctly longer than wide; seventh almost square; eighth to eleventh distinctly wider than long; twelfth about as long as wide at the base. Mandibles elongate, straight, of the usual *Eumenes*-shape; the apex very blunt and slightly curved; inner margin with three superficial notches, the salient portions forming three wide teeth, of which the middle one bears a blunt median projection. Thorax short ovate; seen from above, a little longer than wide, more distinctly longer than high in profile. Pronotum squarely truncate anteriorly, with a fine, continuous rim which extends on the sides to near the front coxae where it is more carinate; the rim avoiding the humeral angles and running in front of them and along the vertical face of the pronotum. Humeral angles very prominent, flattened into sharp crests, as seen from above forming bluntly rounded right angles. Mesonotum slightly longer than wide, its anterior half with a median impressed line bordered by very fine carinae, its posterior half with an impressed line on each side above the tegulae and with shallow traces of notauli close to the scutellum. Scutellum uniformly and moderately convex, with a fine, slightly raised median line in its anterior half; postscutellum moderately convex and wholly within the posterior slope of the thorax. Propodeum, seen from above, short, moderately convex; completely rounded off at the sides, without ridges or projecting angles; its concavity broad and deep, but separated from the postscutellum by a narrow, convex area; the bottom of the concavity with a deep furrow divided into foveolae by short transverse ribs and continued upward to near the postscutellum. First abdominal segment very long and slender; more or less ribbon-shaped; about as long as the thorax and about three to four times as long as its greatest width (the proportions varying rather considerably in our specimens); in profile very slightly but uniformly curved throughout its length; the ventral curve is divided into two shallow bows by a slight blunt tubercle placed on each side of the middle line, on the ventral side of the segment, below and a little before the spiracle; basal third stalk-like, gradually thickened behind, the apical two-thirds not more than twice as thick as the base; seen from above, widening rather rapidly, the apical two-thirds being almost parallel-sided and two and one-half to three times as wide as the basal stalk; its apex with slightly projecting, blunt angles; spiracles slightly protuberant, not visible from above; the apical, wider portion much flattened dorsally, even somewhat depressed before the middle, with a deep, median, longitudinal groove. Second segment depressed, bell-shaped, moderately and evenly swollen dorsally and ventrally, much longer than high or wide; the basal

neck very short; the sternite slightly convex at the base; apex of sternite and tergite simple, flat. Legs normal, slender.

Puncturation dense and coarsely granular on most of head and thorax; finer and very scattered on clypeus, cheeks, lower part of face (below the antennae), and postocellar portion of vertex. Tegulae, anterior portion of mesopleura, metapleura and ventral areas of propodeum almost impunctate. Abdomen practically impunctate; the first tergite without or with very few, microscopic punctures. Pubescence short but rather dense and mostly rufous on head and thorax; very sparse on the abdomen.

Mostly red; the thorax duller, more ferruginous red (Ridgway's burnt sienna), the abdomen brighter, almost orange red (Ridgway's mars orange). The black parts are: last six segments of flagellum above; a transverse fascia on the frons, above the insertion of the antennae; a fascia on the vertex, including the ocellar triangle and extending to the margin of the eyes; posterior face of head; broad posterior and narrow anterior margins of mesonotum, as well as a narrow median line on its anterior half; narrow anterior margins of scutellum and postscutellum; sternum; extreme anterior portion of mesopleura; mesepimera; metapleura; a narrow, median longitudinal line on propodeum; extreme base of first abdominal segment; posterior face of front and middle coxae and most of hind coxae. The extent of the black markings varies slightly. The yellow markings (Ridgway's cadmium yellow) are far more extensive and distributed as follows: clypeus; frons below the ocelli, except the black supra-antennal fascia, but including the sinuses of the eyes; a line along each outer orbit, the two lines connecting across the vertex behind the ocelli; mandibles, except their margins and tip; sometimes the under side of the antennal scape; pronotum (with small, indefinite ferruginous blotches dorsally); most of scutellum and postscutellum; most of propodeum (three connected ferruginous spots in the upper dorsal half, and ferruginous blotches on the sides); most of mesepisterna; tegulae (more or less ferruginous in the center); an apical fascia on the first abdominal segment, very narrow on the tergite, broader and produced anteriorly in the middle on the sternite; a narrow pre-apical fascia on the second segment, generally irregular and often suffused with ferruginous so as almost to disappear; under side of femora more or less extensively, and most of front and middle tibiae, as well as blotches on the tarsi (the yellow and ferruginous of the legs more or less intergrading). Wings very slightly infusate; distinctly amber yellow in their basal half, a little darker and slightly purplish in their apical half; stigma amber yellow; veins brown, more ferruginous in the basal half.

Male.—Similar to the female, except for the following differences. Eyes much closer together at the clypeus than on the vertex; posterior ocelli almost twice as far apart as from the eyes. Clypeus one and one-half times as long as wide, almost elongate hexagonal; the anterior, free portion about two-thirds the length of the upper, interocular part; the apical margin as in the female. Antenna much elongate, most of the segments of the flagellum longer than wide; thirteenth segment very large, folded beneath so that its apex reaches the base of the eleventh

segment, in profile shaped like a duck's head; its dorsal face with a prominent, wide hump which is abruptly truncate distally, so as to form a sharp edge; the face of the truncation with a short, oblique ridge in its upper part; the apical portion of the segment finger-shaped, not carinate, with blunt point, and about as long as the upper edge of the basal, swollen portion. Last abdominal sternite uniformly flattened throughout. The genitalia are of the usual *Eumenes*-type; the shaft of the penis is slender throughout, slightly expanded and bluntly rounded at the apex.

Flagellum more extensively black than in the female. Apical sternite of abdomen black.

CUBA. Santiago de Cuba (A. M. N. H.; U. S. N. M.). Havana (C. F. Baker.—Corn. Univ.). Guanabo, Havana (Bromley). Santiago de las Vegas, common (Est. Agr. C.). Hoyo Colorado (C. Enamorado). Cienaga, Prov. Havana (M. C. Z.). La Mina, near Cienfuegos; Soledad, several specimens, including the holotype (♀) and allotype (♂) at M. C. Z. (George Salt). Preston, Oriente (J. Bequaert). One male and one female, labelled "Cuba" (A. N. S. Phila.). Specimens here listed (except holotype and allotype) are paratypes.

***Eumenes confusus* var. *pinetorum*, new variety.**

Eumenes ferruginea Holland, 1917, Ann. Carnegie Mus., XI, p. 293. Not of Cresson, 1865.

A pair (holotype ♀ and allotype ♂) from Nueva Gerona, ISLE OF PINES (G. Link), at the Carnegie Museum, Pittsburgh, agree structurally with the Cuban *E. confusus*, but represent a distinct color form, in which the yellow markings are much reduced. Another pair (paratypes), from the same source, are at the United States National Museum. A third pair (paratypes), bred from a nest also found at Nueva Gerona by S. C. Bruner and Y. L. Bouclé, September 4–12, 1928, is at the M. C. Z.

Length (h. + th. + t. 1 + 2) : ♀, 15.5 to 17.5 mm.; ♂, 15 to 16.5 mm.

Female.—The body is uniformly ferruginous red (Ridgway's mahogany red). The few black markings are about as in the typical form, as are also the yellow markings of the head, abdomen and legs. On the thorax, however, the yellow color (Ridgway's light cadmium) is confined to the postscutellum, ill-defined blotches on the posterior portion of the mesepisterna, the inner corners of the tegulae, and faint traces along the lateral and inferior ridges of the propodeum (more distinct at the apex). The color of the wings shows no difference.

Male.—Colored much like the female.

***Eumenes abdominalis* (Drury) var. *hispaniolae*, new variety.**

Eumenes abdominalis var. *colona* H. de Saussure, 1875, *Smithson. Miscell. Coll.*, XIV, No. 254, p. 107 (in part). Dalla Torre, 1894, 'Cat. Hym.', IX, p. 16 (in part).

Eumenes colona Ashmead, 1900, *Trans. Ent. Soc. London*, p. 312 (in part).

Eumenes abdominalis colona W. A. Schulz, 1903, *Sitzungsber. Math. Phys. Kl. Akad. Wiss. München*, XXXIII, Heft 3, p. 483 (♀).

Eumenes (Zela) colonus Zavattari, 1912, *Arch. f. Naturgesch.*, LXXVIII, Abt. A, Heft 4, p. 126 (♀ ♂).

Female.—Head black; clypeus, a broad spot between the antennae, inner orbits from the clypeus to the upper margin of the sinus of the eyes, a transverse stripe between frons and vertex, and outer orbits, sulphur yellow; mandibles ferruginous with a yellow stripe; antennae ferruginous in their basal half, the apical half black above, ferruginous beneath. Thorax mostly sulphur yellow (Ridgway's light cadmium); the narrow sutures, a broad longitudinal stripe over the anterior two-thirds of the mesonotum (much widened anteriorly and rounded posteriorly), the posterior margin of the mesonotum, the anterior margin of the scutellum, sometimes a small spot on the sides of the pronotum (above the coxae), the sternum, the anterior and posterior portion of the mesopleura, the metapleura, and the outer margins and middle line of the propodeum, black; tegulae ferruginous. First abdominal segment black, suffused with ferruginous before the apex, and with a broad, apical yellow fascia dorsally and ventrally; extreme base of the second segment black; remainder of abdomen ferruginous to chestnut (Ridgway's burnt sienna to chestnut), rather diffusely marked with yellow ventrally. Second tergite with a narrow, apical, yellow fascia, somewhat widened in the middle line. Legs ferruginous red; coxae and trochanters black; tibiae indistinctly spotted with yellow. Wings very slightly infusate, distinctly amber yellow in their basal half, a little darker and somewhat purplish in their apical half; stigma amber yellow; veins brown, more ferruginous in the basal half.

Male.—Extremely similar to the female. The only differences we can discover are that the yellow interantennal mark is fused with the yellow inner orbits above the clypeus, and that the transverse stripe below the ocelli is reduced and broadly interrupted in the middle.

SANTO DOMINGO. Port-au-Prince, Haiti, one female, holotype (M. C. Z.), and one female, paratype (G. N. Wolcott.—U. S. N. M.). Haiti, without more definite locality, one male, allotype (U. S. N. M.).

***Ancistrocerus* (*Ancistrocerus*) *domingensis*, new species.**

A medium-sized, rather stubby species. Black, with a few ivory-white markings on head and thorax and ivory-white apical fasciae on first, second and third abdominal tergites and on second sternite.

Length (h. + th. + t. 1 + 2) : ♂, 7 mm.

Male.—Head, seen in front, subcircular, very slightly wider than high; seen from above, transverse, less than twice as wide as long, slightly wider than the thorax; occipital margin distinctly, but very evenly concave. Vertex and cheeks margined throughout by a sharp carina which is slightly higher along the cheeks than on the vertex. Cheeks moderately wide, distinctly swollen in their upper half (the swollen portion almost forming a blunt ridge behind the outer upper orbits), about half as wide as the upper part of the eye in profile, rather abruptly narrowed in their lower third where the carina is broadly rounded and forms a very slight angle. Inner orbits a little more than twice as far apart on the vertex than at the clypeus. Upper half of frons hardly swollen. Eyes unusually large and rather bulging. Ocelli in a slightly flattened triangle; the posterior pair nearly twice as far apart as from the eyes and even farther from the occipital margin than from each other. Interocellar area flat; vertex without fovea. Antennae much farther apart than from the inner orbits and rather far from the upper margin of the clypeus; the ridge between them hardly developed, except in the upper part where it is very low and blunt. Clypeus irregularly pentagonal, about as long as its greatest width which is at the lower third, hardly convex and slightly grooved in the middle of its lower half; the anterior, free portion less than half the length of the upper, interocular part; the slight, regularly arcuate emargination of the apex nearly one-third of the greatest width of the clypeus, with sharp but short lateral angles. Antenna moderately elongate; flagellum conspicuously swollen in its apical third, with most of the segments bead-like; scape short, slightly curved, less than one-fourth the length of the flagellum; third antennal segment one and one-half times the length of the fourth; fourth to seventh decreasingly longer than wide; eighth to tenth wider than long; eleventh one and one-third times as long as wide at base, excavated beneath; twelfth larger than usual, nearly as long as the next; thirteenth (hook) moderately long, distinctly flattened, in profile from above triangular, with sharp, slightly curved tip which reaches the apex of the tenth segment, from below broadly triangular with very bluntly rounded apex. Mandible only half the length of the eye, tapering rapidly from a broad base to a very sharp, moderately curved apex; inner margin with very superficial notches; outer surface with two fine, longitudinal, converging ridges, which meet far before the apex. Thorax elongate rectangular, one and one-third times as long as wide and slightly wider than high, slightly narrowed anteriorly and posteriorly, a little more so anteriorly. Pronotum not narrowed behind the humeral angles; anterior margin almost straight dorsally (very slightly curved inwardly), with a strongly raised, translucent lamella stopping abruptly at the humeral angles, below which a blunt carina runs to near the front coxa; humeral angles, seen from above, very slightly projecting, bluntly rounded, not tuberculate. Mesonotum slightly longer than wide, elongate pentagonal with the anterior half produced, distinctly convex; notauli indicated in the posterior fourth only. Tegula longer than wide, with broadly rounded outer margin, of normal shape; posttegula small, finger-shaped and curved. Scutellum rectangular; its

median portion (between the deep lateral grooves) about twice as wide as long, flat, faintly depressed in the middle close to the hind margin; without tubercles or carinae; suture dividing it from the mesonotum coarsely foveolate. Postscutellum without tubercles or median depressions; its median portion irregularly pentagonal with rounded angles, about as long as the scutellum and nearly twice as wide at the anterior margin as long in the middle, separated on each side by a fine carina from the lateral, somewhat pitted depressions; a deep pit in the anterior corner, within the carina; its surface flat anteriorly, slightly sloping in the posterior third, the edge between the two areas somewhat raised. Mesepisternal suture continuous; no trace of epicnemial carina. Propodeum long, vertically truncate and deeply concave behind, not swollen on the sides; dorsal areas touching each other in the middle over a long distance (about one-third of the length of the postscutellum), the postscutellum broadly separated from the concavity by a slightly sloping area; superior ridge slightly raised into a very fine carina; lateral ridge and upper half of inferior ridge bluntly rounded; lower half of inferior ridge forming a somewhat translucent lamella which is united with the valvula; concavity wide, moderately deep, divided throughout by a longitudinal furrow; lateral angles broadly rounded, not produced. Abdomen rather stubby. First tergite short, transverse, very little narrower than the second, in outline cup-shaped with strongly angular sides, about one and one-third times as wide as long; its horizontal face, in profile, about half the length of the second tergite; its anterior vertical face sloping rather abruptly and forming a distinct angle with the posterior, horizontal portion; the two areas separated by a high, straight, regular carina; the carina limited behind by a depression and, seen from above, projecting on each side as a broadly rounded angle; its lateral extensions joining the slightly thickened apical margin of the tergite; its horizontal portion convex, with a slight median depression before the apex, not longer in the middle than at the sides, widest at the apical margin where its width is about one and two-thirds times its length in the middle. Second segment about as long as wide at apex, much more convex dorsally than ventrally; its apical margin simple, straight, not thickened, very narrowly translucent at the extreme edge; its dorsal surface normal, very faintly flattened in the middle before the apical margin; its base apparently not forming a mite chamber, the transverse furrow behind the articulation smooth, not foveolate; its sternite very gradually sloping and gently rounded toward the base, without median depression and without riblets or foveolae in the furrow behind the articulation. Legs rather stout and short; femora somewhat swollen, of normal shape; claws almost entire, with a very slight notch on the inner side before the apex. Wings with the usual type of venation; radial cell strongly and rather rapidly widened opposite the second cubital, truncate at apex with a distinct appendicular vein; third cubital much longer than high; stigma much wider than usual. Genitalia of the usual shape; the shaft of the penis slender throughout, without basal lobules or expansions (tip broken off).

Head and thorax with fine and scattered punctures, which are a little larger on the frons and on the posterior fourth of the mesonotum; clypeus, tegulae, scutellum, postscutellum, anterior and posterior slopes of mesopleura, and metapleura almost impunctate; propodeum mostly smooth, the dorsal areas posteriorly and the ventral areas with a few fine punctures. Abdomen with extremely minute, scattered punctures, especially small on the horizontal portion of the first tergite (which is almost impunctate under the hand-lens); punctures much more distinct and numerous (although no larger) before the apex of the second and following segments. Body covered with a short, silky, silvery white, appressed tomentum, especially noticeable on the clypeus, pleura and propodeum, without longer pubescence.

Black, with the following areas ivory-white (Ridgway's cream color): clypeus (except for a narrow median mark in the lower half, filling the bottom of the preapical groove); a wedge-shaped spot on the inter-antennal ridge down to the clypeus; very narrow inner orbits from the clypeus to the bottom of the ocular sinuses; a narrow streak on the swollen, upper part of the cheek (some distance behind the outer orbit); a large streak on the mandibles; dorsal anterior margin of pronotum very narrowly; anterior and posterior portions of tegula; raised lower portion of the inferior ridge of the propodeum; an elongate, vertical spot beneath the tegula, covering the hind portion of the upper plate of the mesepisternum; a narrow, continuous fascia along the hind margin of the scutellum, reaching the insertions of the wings; a narrow apical fascia on the first abdominal tergite; a broader apical fascia, somewhat dilated on the sides, on the second tergite and sternite; a very narrow apical fascia, not reaching the sides, on the third tergite; a spot near the apices of the front and middle femora; a line along the outer side of the front and middle tibiae (dilated near the apex of the former); and an elongate spot on the outer basal half of the hind tibiae. Anterior half of fore wing strongly infuscate with a purplish tinge (over most of the costal, the apical half of the median, the entire radial and most of the four cubital cells); remainder of the wings moderately smoky to subhyaline; stigma and veins dark brown.

SANTO DOMINGO: One male, holotype, without more definite locality (M. C. Z.).

Ancistrocerus (Parancistrocerus) atkinsi, new species.

A small, cylindrical species. Black, with numerous lemon yellow markings on head and thorax, apical yellow fasciae on the first, second, fourth, and fifth abdominal tergites and the second tergite, and lateral yellow spots at the base of the second tergite.

Length (h. + th. + t. 1 + 2) : ♀, 7 mm.

Female.—Head, seen in front, circular; seen from above, transverse but long, less than twice as wide as long, not wider than the thorax;

occipital margin nearly straight. Vertex and cheeks margined throughout by a carina, which is well marked on the occiput but higher along the cheeks. Cheeks moderately wide and hardly swollen in their upper half, considerably narrowed at the lower third where the marginal carina forms a broadly rounded, obtuse angle. Inner orbits one and one-half times as far apart on the vertex as at the clypeus. Upper half of frons moderately swollen. Ocelli in a flattened triangle, the posterior ocelli distinctly farther apart than from the eyes. Interocellar area flat; vertex with a pair of minute hairy foveae far removed from the occiput. Antennae almost twice as far apart as from the inner orbits; the ridge between them rather bluntly raised in its lower half. Clypeus very broadly pyriform, a little wider than long, slightly convex basally, somewhat depressed medially in its apical half; the anterior, free portion about as long as the upper, interocular part; the truncate apex about one-fourth the greatest width of the clypeus, with a slight inward curve, preceded by a narrow, shiny, but not depressed area; lateral angles of apex somewhat projecting, blunt, each with a low ridge which continues more or less distinctly over the lower third of the clypeus. Antenna short; flagellum a little thickened in the apical half; scape slender, distinctly curved, a little less than half the length of the flagellum; third antennal segment rather short, but distinctly longer than the fourth; fourth, fifth, and sixth almost square; seventh to eleventh wider than long; twelfth hardly longer than wide at the base. Mandible much shorter than the length of the eye, straight, ending in a short, obtuse tooth; inner margin with three superficial notches separating broad, low, blunt teeth. Thorax barrel-shaped, more distinctly narrowed posteriorly than anteriorly, one and one-half times as long as its greatest width and about as high as wide. Pronotum distinctly narrowed toward the anterior margin, which is squarely truncate and carinate; on the sides the carina is high and runs from the sharp humeral angles to the coxa; dorsally it is much finer and broadly interrupted in the middle; the carina forms the humeral angles which, however, are not raised or projecting. Mesonotum a little longer than wide, pentagonal in outline with the anterior third produced; very slightly convex, with slight traces of notauli close to the scutellum. Tegula about as wide as long, with broadly rounded outer margin, of normal shape; posttegula rather large, rectangular, very slightly curved. Scutellum rectangular, one and one-half times as wide as long, flat in its anterior half, somewhat raised posteriorly where it bears a fine, median, longitudinal impression, without tubercles or carinae; the deep sutures separating it from mesonotum and postscutellum finely and regularly foveolate. Postscutellum transversely elliptical, about half as long as the scutellum, moderately convex throughout and somewhat sloping posteriorly, without ridges, tubercles, or depressions. Mesepisternal suture continuous; epicnemial carina distinct, though blunt, beginning at the mesepisternal suture and extending to near the base of the middle coxa. Propodeum moderately long, squarely and vertically truncate behind, hardly swollen on the sides; dorsal areas touching each other in the middle over an extremely short, depressed space which distinctly separates the postscutellum from the concavity; concavity

wide, shallowly depressed, divided throughout by a fine longitudinal carina which does not attain the upper edge and is not connected with the superior ridges; superior ridges barely carinate, but with a series of sharp serrulations, those of the extreme upper edge not much stronger than the others; lateral and inferior ridges rounded; lateral angles not produced, broadly rounded. Abdomen elongate, moderately slender. First tergite short, transverse, cup-shaped in outline with rounded sides, about one and one-half times as wide as long and a little narrower than the second; its horizontal face, in profile, more than half the length of the second tergite; its anterior face sloping rather abruptly, but not forming a distinct angle with the posterior, horizontal portion; the two areas separated by a sharp, but rather irregular, transverse carina which appears to be produced by a series of very coarse punctures rather than by a formal ridge; its horizontal area much wider in the middle than on the sides, without median depression; its hind margin slightly thickened, somewhat produced in the middle, covering the depressed base of the second tergite; its extreme edge narrowly translucent and somewhat jagged. Second segment broadly barrel-shaped, somewhat more narrowed anteriorly than posteriorly, slightly wider than long, moderately and about equally convex dorsally and ventrally; its apical margin simple, without raised or depressed lamella, very slightly thickened and narrowly translucent along the extreme edge; its sternite gradually sloping and broadly rounded anteriorly, with a median longitudinal furrow in the basal third, and a row of pronounced, longitudinal riblets in the transverse furrow behind the basal articulation. The depressed basal neck of the second tergite forms no mite chamber. Legs rather slender, of normal shape. Wing venation: radial cell rather abruptly and considerably widened opposite the second cubital, very broadly rounded at the apex, not appendiculate; third cubital much higher than long.

Head and thorax densely covered with deep and large punctures, which are somewhat smaller and sparser on the upper half of the clypeus, between the antennae, in the sinus of the eye, on the cheeks, and on the mesopleura; lower half of the clypeus with large but rather superficial punctures, separated by irregular, faint striae; concavity of propodeum rugoso-reticulate in the upper half, densely and coarsely punctate in the lower half; tegulae and posttegulae impunctate. First abdominal tergite very coarsely and densely punctate; the punctures deeper and larger toward the transverse carina; behind the large, foveolate punctures that limit the carina there is, on each side, a narrow, irregular, impunctate space. Remainder of abdomen with fine and sparse, but distinct punctures which are stronger dorsally than ventrally and denser in the apical third of the second tergite. Body shiny, almost bare; head and thorax with extremely short, grayish pile.

Black. Basal half of clypeus (squarely emarginate with black anteriorly), a wedge-shaped spot between the antennae, the whole of the ocular sinuses, most of the upper half of the cheeks, a spot on the base of the mandibles, entire scape of antenna, anterior half of pronotum (not interrupted in the middle), a large, square, median spot in the posterior third of the mesonotum, postscutellum, tegulae, post-

tegulae, most of the dorsal and ventral areas of the propodeum (the yellow extending over the lateral angles to cover the lower sides of the concavity), upper plate of mesepisternum, apical margin of first tergite (very wide in the middle and gradually narrowed toward the sides), a broad apical margin on second tergite and sternite (somewhat wavy anteriorly), an oval spot on each side of second tergite very close to the base, broad apical fasciae on fourth and fifth tergites (ending far from the sides), and most of the legs, bright lemon yellow (Ridgway's lemon chrome). Flagellum of antenna ferruginous brown, dorsally darker; apical half of mandibles and much of the tarsi ferruginous. Coxae, trochanters, and hind femora (except extreme tip), black. Wings subhyaline, more infusate in the radial cell which is slightly purplish; median cell mostly amber yellow; stigma amber yellow; veins brown, more yellowish toward the dorsal margin.

CUBA. La Milpa near Cienfuegos, July 4, 1925, one female, holotype (George Salt.—M. C. Z.). San Diego de los Baños, April, one female, paratype (Palmer and Riley.—U. S. N. M.).

Ancistrocerus (Parancistrocerus) lutzi, new species.

A small, cylindrical species. Black, with numerous pale yellow markings on head and thorax, pale yellow apical fasciae on the first, second, fourth, fifth, and (in the male) sixth abdominal tergites, and on the second and third sternites, and lateral yellowish dots at the base of the second or first and second tergites.

Length (h. + th. + t. 1 + 2): ♀, 6 to 6.5 mm.; ♂, 4.5 to 6 mm.

Female.—Head, seen in front, circular; seen from above, transverse but long, less than twice as wide as long; occipital margin with a decided inward curve. Vertex and cheeks margined throughout by a carina which is low but distinct on the occiput and very high along the cheeks. Upper half of the cheeks narrower than in *A. dejectus* (Cresson), but more swollen, gradually narrowed at the lower third where the carina forms no angle. Eyes one and one-third times as far apart on the vertex as at the clypeus. Upper half of the frons moderately swollen. Ocelli in a flattened triangle; posterior ocelli distinctly farther apart than from the eyes. Interocellar area almost flat, very slightly raised near the posterior ocelli; vertex with a pair of minute, hairy foveae far removed from the occiput. Antennae almost twice as far apart as from the inner orbits; the ridge between them rather bluntly raised in its lower half, with a deep impressed line in its upper half. Clypeus broadly pyriform, about as wide as long, slightly convex basally, somewhat flattened medially in its apical half; its anterior, free portion about one and one-third times the length of the upper, interocular part; its truncate apex about one-fourth the greatest width of the clypeus, with a moder-

ately deep inward curve preceded by a narrow, shiny, but not depressed area; lateral angles of apex forming strongly projecting, blunt teeth in each of which ends a short, distinct ridge. Antenna short; flagellum very gradually thickened toward the apical half; scape slender, distinctly curved, much less than half the length of the flagellum; third antennal segment a little longer than the fourth; fourth slightly longer than wide; fifth almost square; sixth to eleventh a little wider than long; twelfth a little longer than wide at the base. Mandible of the usual shape, considerably shorter than the length of the eye, straight, ending in a broad, obtuse, slightly curved tooth; inner margin with three deep notches separating broad, low, blunt teeth. Thorax barrel-shaped, more distinctly narrowed posteriorly than anteriorly, one and one-half times as long as its greatest width and about as high as wide. Pronotum distinctly narrowed toward the anterior margin which is squarely truncate and carinate; on the sides the carina is high and runs from the sharp humeral angles to the coxae; dorsally it is much finer and broadly interrupted in the middle; the carina forms the humeral angles which, however, are not raised or projecting. Mesonotum a little longer than wide, pentagonal in outline with the anterior third produced, very slightly convex, with slight traces of notauli close to the scutellum, and with a fine, impressed, median, longitudinal line over the anterior third. Tegula slightly longer than wide, with broadly rounded outer margin, of normal shape; posttegula large, rectangular, not curved, flat. Scutellum rectangular, a little less than twice as wide as long, flattened throughout, with the merest trace of a median longitudinal line, without tubercles or carinae; the deep suture separating it from the mesonotum coarsely foveolate; the suture separating it from the postscutellum finely foveolate. Postscutellum transversely elliptical, nearly two-thirds the length of the scutellum, moderately convex throughout, slightly sloping posteriorly, without ridges, tubercles, or depressions. Mesepisternal suture continuous; epicnemial carina distinct, though blunt, beginning at the mesepisternal suture and extending to near the base of the middle coxa. Propodeum moderately long, squarely and vertically truncate behind, hardly swollen on the sides; dorsal areas touching each other in the middle over an extremely short, depressed space which distinctly separates the postscutellum from the concavity; concavity wide and rather deep, divided throughout by a fine longitudinal carina which expands and divides at the upper edge to join the superior ridge on each side; superior ridges very finely and irregularly carinate, the carina higher and somewhat wavy in the upper part but not forming a sharp crest; lateral ridges rounded; inferior ridges somewhat angular but not carinate; lateral angles indistinct, in profile slightly more projecting than the upper edge of the superior ridge, broadly rounded. Abdomen elongate, quite slender. First tergite short, transverse, cup-shaped in outline with rounded sides, about one and one-half times as wide as long and a little narrower than the second; its horizontal face, in profile, more than half the length of the second tergite; its anterior, vertical face sloping abruptly but not forming a distinct angle with the posterior, horizontal portion; the two areas separated by a sharp, rather irregular, transverse carina which

appears to be produced by a series of foveolae rather than by a formal ridge, and which is more marked on the sides than in the middle; its horizontal area slightly wider in the middle than on the sides, without median depression; its hind margin hardly thickened, not produced in the middle, covering the depressed base of the second tergite; its extreme edge narrowly translucent and somewhat jagged. Second segment broadly barrel-shaped, somewhat narrower anteriorly than posteriorly, a little wider than long, moderately and about equally convex dorsally and ventrally, not ending in a depressed lamella; its apical margin slightly thickened and preceded by a distinct, though shallow transverse groove; its extreme edge narrowly translucent and serrulate; the anterior limit of the preapical groove with a low but distinct, somewhat transverse swelling on each side of the middle line; its sternite gradually sloping and broadly rounded anteriorly, with a median, longitudinal furrow in its basal third, with a row of pronounced longitudinal riblets in the transverse furrow behind the basal articulation, and with a slight transverse swelling on each side a short distance from the apical margin (less pronounced than that of the tergite). The depressed basal neck of the second tergite forms no mite chamber. Legs rather stout, of normal shape. Wing venation: radial cell gradually but rather considerably widened opposite the second cubital, broadly rounded at apex, with a stump of appendicular vein; third cubital much higher than long.

Head densely covered with coarse punctures which are finer on the interocellar area and on the cheeks; raised interantennal area, lower inner orbits, and ocular sinuses without coarse sculpture, smooth under the hand-lens but with an extremely fine, microscopic puncturation. The punctures of the clypeus medium-sized and scattered, somewhat more numerous than in *A. dejectus*; the irregular, longitudinal striation of the lower half more distinct than in that species. Dorsal surface of thorax uniformly covered with dense and coarse punctures, leaving no smooth intervening spaces except in the center close to the scutellum; the punctures a little more distinct on the scutellum and much smaller and sparser on the postscutellum and mesopleura; anterior and posterior slopes of mesopleura, metapleura, and sternum almost impunctate. Tegulae and posttegulae without coarse sculpture, but densely covered with microscopic punctures. Dorsal areas of propodeum reticulato-punctate; ventral areas with scattered, medium-sized punctures; sculpture of concavity as in *A. dejectus*. First abdominal tergite sculptured as in *A. dejectus*, but the puncturation of the remainder of the abdomen much stronger and more abundant, especially on the sides and in the preapical, shallow grooves of the second tergite and sternite. The disk of the third sternite almost entirely covered with a maze of large, deep pits. Body shiny. Head with short, grayish pile; thorax and abdomen with short, silvery pubescence which is densest and longest over the pitted disk of the third sternite.

Black. Basal third of clypeus (arcuately emarginate with black anteriorly), an elongate median spot on the frons above the insertion of the antennae, whole of the ocular sinuses, a narrow elongate spot on the upper half of the cheeks, broad under side of the antennal scape, a

small triangular spot on the base of the mandibles, anterior third of pronotum (broadly interrupted in the middle), a large, rectangular, median spot in the posterior third of the mesonotum, postscutellum, tegulae, posttegulae, large lateral spots on the propodeum (covering the lateral angles and the inferior ridges and extending somewhat over the dorsal and lateral areas and the sides of the concavity), upper plate of the mesepisternum, apical margin of first tergite (very slightly wider in the middle), a small, transverse, lateral spot on each side of the first tergite behind the carina, apical margin of second tergite and sternite, a round spot on each side of the second tergite a little distance from the base, apical fasciae on the fourth and fifth tergites (not reaching the sides) and on the third sternite, apical fourth of the front and middle femora, a dot at the apex of the hind femora, and most of the outer side of all the tibiae, pale yellow (Ridgway's pinard to empire yellows). Under side of flagellum, apex of mandible, and tarsi more or less ferruginous; a pale ferruginous spot in the center of the tegulae. Wings subhyaline, more infuscate and slightly purplish in the radial cell; costa pale brown, the other veins and the stigma dark brown.

Male.—Very similar in structure and sculpture to the female, except for the following points. Cheeks narrower in their upper half, narrower but somewhat more swollen than in the male of *A. dejectus*. Eyes a little less than twice as far apart on the vertex as at the clypeus. Interocellar area with a slight longitudinal depression and distinctly raised beside the posterior ocelli. Vertex without foveae. Clypeus pentagonal with rounded edges, moderately convex, with a little swelling on each side above the middle, about as wide as long; its apical, free portion about as long as the basal, interocular part; its apex deeply, almost semicircularly emarginate, forming two narrow, triangular, blunt teeth (the emargination appears to be much deeper owing to a preapical, translucent depression). Antenna more slender; flagellum slightly thickened in the apical half; scape less than one-fourth the length of the flagellum; third and fourth antennal segments much longer than wide and of about equal length; fifth a little shorter than fourth; sixth to eleventh a little longer than wide; twelfth small; thirteenth (hook) finger-shaped, longer and narrower than in *A. dejectus*, slender, slightly curved, the rather narrow but blunt tip reaching the apex of the tenth segment. Humeral angles sharper and slightly more projecting than in the female. Preapical transverse groove of the second tergite more distinct, as are also the transverse swellings of second tergite and sternite. Clypeus with fine scattered punctures, visible with the hand-lens, without striae. The pits which cover the disk of the third sternite even larger and deeper than in the female.

The pale yellow markings differ from those of the female as follows: clypeus entirely yellow; frontal spot between the insertions of the antennae extending to the clypeus; spot in the ocular sinus continuing some distance along the lower inner orbit; outer surface of mandible almost entirely yellow; lateral spots of propodeum much smaller or lacking; lateral spots of first tergite sometimes absent; sixth tergite also with an apical fascia (not reaching the sides); femora more extensively yellow; middle and hind coxae with a large yellow spot beneath.

SANTO DOMINGO. Fond Parisien, Haiti, one female, holotype, one male, allotype, and four males, paratypes, February 11 to 18, 1922; Port-de-Paix, Haiti, one female, paratype, October 25, 1923 (A. M. N. H.). Port-au-Prince, Haiti, one male, paratype (G. N. Wolcott.—U. S. N. M.).

Ancistrocerus (Parancistrocerus) olseni, new species.

A medium-sized, moderately slender species. Black, with numerous yellow markings on head and thorax, yellow apical fasciae on the first and second tergites and second sternite, and yellow spot, near the base of the second tergite, and with the propodeum, first abdominal tergite, and legs partly ferruginous red.

Length (h. + th. + t. 1 + 2): ♀, 8 mm.

Female.—This species is structurally so close to *A. obliquus* (Cresson) that it will suffice to point out the differences. Third antennal segment one and one-half times the length of the fourth. Anterior margin of pronotum dorsally with an extremely fine, translucent carina which is very broadly interrupted in the middle (the median fourth of the margin smoothly rounded) and which runs over the humeral angles; laterally the carina is high and extends to the base of the coxa. Humeral angles much more prominent, their sharp apices somewhat curved outwardly. Posttegula broader, rectangular with rounded apex, not curved. Sides of postscutellum slightly raised into low, smooth swellings. Epicnemial carina well marked in the lower half, gradually effaced toward the mesepisternal suture. Dorsal areas of propodeum more broadly contiguous in the middle line, the concavity more distant from the postscutellum. Abdomen more stubby. First tergite relatively wider and shorter, only slightly narrower at the apex than the base of the second; its horizontal face about one and one-half times as wide as long, separated from the anterior, sloping face by a much finer, irregular, but well-defined and straight carina; apical margin not covering a mite chamber at the base of the second tergite. Second segment more strongly swollen dorsally and ventrally, the hump on the tergite more pronounced and situated more anteriorly.

The puncturation is totally different from that of *A. obliquus*. Head and thorax almost entirely covered with very coarse and dense punctures, the narrow lines separating them forming an irregular striation in the posterior third of the mesonotum; the punctures fine but numerous on the vertex, cheeks, scutellum, postscutellum, mesopleura, and ventral areas of the propodeum; even finer and less abundant on the upper half of the clypeus, upper plate of mesepisternum, metapleura and tegulae; sinuses of the eyes and interantennal area smooth and impunctate. On the apical half of the clypeus the irregular longitudinal striation is better defined than in *A. obliquus*. Concavity and dorsal areas of propodeum very coarsely rugoso-punctate, the

rugosities tending to form transverse striae over the rounded superior ridges. Puncturation of first abdominal tergite, behind the carina, very coarse and more or less reticulate in the anterior half, medium-sized in the middle, much finer in the apical third. The punctures of the remainder of the abdomen much finer and sparser than elsewhere on the body, though larger and more numerous than in *A. obliquus*. Pubescence as in *A. obliquus*.

Black. The following parts bright yellow (Ridgway's lemon chrome): basal three-fifths of the clypeus, a wedge-shaped spot between the antennae, whole of the ocular sinuses, major part of the cheeks, a triangular spot at the base of the mandibles, scape of the antennae, anterior half of pronotum, most of scutellum and postscutellum, tegulae, posttegulae, a broad spot in the upper half of mesopleura, sides of propodeum (less extensively than in *A. obliquus*), apical margin of first tergite (gradually widened toward the middle), broad apical margin of second tergite and sternite, a triangular spot on each side at the base of the second tergite, most of the apical half of front and middle femora, and most of the tibiae. Base and under side of flagellum, apex of mandible, most of dorsal areas of propodeum (continued laterally), most of metapleura, basal half of first tergite, first sternite, base of second sternite, coxae, trochanters, basal half of front and middle femora, hind femora, inner side and apex of tibiae, and tarsi, ferruginous to reddish brown (Ridgway's burnt sienna to mahogany). Wings in their basal two-thirds subhyaline with a distinct amber yellow tinge, the veins of that part and the stigma also yellowish; apical third smoky and distinctly purplish, the veins dark brown.

BAHAMAS. Mangrove Cay, Andros Island, one female, holotype, June 24, 1924 (C. E. Olsen.—M. C. Z.).

***Odynerus (Rygchium) haitiensis*, new species.**

A medium-sized, stubby species. Ferruginous red, with numerous yellow markings on head and thorax and yellow apical fasciae on some of the abdominal segments.

Length (h. + th. + t. 1 + 2): ♀, 10 mm.

Female.—Head, seen in front, subcircular, about as high as wide; seen from above, transverse, less than twice as wide as long; occipital margin almost straight. Vertex and cheeks margined throughout by a sharp carina, which is somewhat higher on the occiput. Cheeks wide and distinctly swollen in their upper half, where they are about as wide as the upper part of the eye in profile, gradually narrowed in their lower third; the marginal carina broadly rounded, not forming an angle. Inner orbits very little farther apart on the vertex than at the clypeus. Upper half of the frons hardly swollen. Ocelli in a flattened triangle; posterior pair about as far apart as from the eyes and about twice as far from the occipital margin as from each other. Interocellar area flat. Vertex with a pair of minute foveae a short distance from

the occipital margin. Antennae a little farther apart than from the inner orbits; area between them moderately raised into a uniform, blunt ridge; from the upper end of the ridge a fine impressed line extends to a minute, smooth pit in the middle of the frons. Clypeus broadly pyriform, about as wide as long, moderately convex, slightly flattened in the middle over its apical half; its anterior, free portion as long as the upper, interocular part; its truncate apex about one-third of the greatest width of the clypeus, with a very slight inward curve, forming right angles with the lateral margins; lateral angles of apex hardly projecting, sharp, and somewhat raised longitudinally. Antenna short; flagellum almost uniformly swollen throughout; scape slender, a little over one-third the length of the flagellum, distinctly curved; third antennal segment about one and one-half times the length of the fourth; fourth almost square; fifth to eleventh slightly wider than long; twelfth about as long as wide at the base. Mandible much shorter than the length of the eye, stout, straight; apex forming a blunt, slightly curved tooth; inner margin with three notches separating broad, low, blunt teeth. Maxillary palpi of six segments, the three terminal segments long and slender, together much longer than the third. Labial palpi of four segments, the fourth a little over one-third the length of the third. Thorax rectangular, stubby, very slightly and equally narrowed anteriorly and posteriorly, a little over one and one-third times as long as its greatest width and about as wide as high. Pronotum slightly narrowed toward the anterior margin, which shows a deep but regular inward curve and bears a continuous, sharp, transverse carina, raised dorsally into a somewhat translucent lamella and continued over the humeral angles to the coxae; humeral angle bluntly rounded but distinct, not projecting anteriorly and emitting no carina toward the hind margin of the pronotum. Mesonotum distinctly longer than wide, pentagonal in outline with the anterior third produced and the anterior angle broadly rounded, almost flat; without notauli. Tegula very little longer than wide, its hind margin forming a continuous curve with the outer margin; posttegula very small, finger-shaped, straight. Scutellum rectangular, about twice as wide as long, almost flat, with a faint trace of an impressed, median, longitudinal line, without tubercles or carinae; suture separating it from the mesonotum minutely foveolate. Post-scutellum transversely elliptical; seen from above, about half the length of the scutellum, without depression or tubercles; moderately swollen throughout, with a short, anterior, horizontal area and a longer, vertical, posterior portion; the two areas separated by a finely crenulate ridge, which is somewhat lower in the middle. Mesepisternal suture continuous; epicnemial carina only faintly indicated in its lower portion. Propodeum short, squarely and vertically truncate behind, hardly swollen on the sides; dorsal areas very broadly separated from each other by the postscutellum, the vertical face of which is continuous with the concavity; concavity wide and shallowly depressed, divided in the middle by a smooth, longitudinal carina, which is broad in the lower half and fine in the upper half where it reaches the postscutellum; superior ridge well marked, with a fine, irregular carina which is

separated from the postscutellum by a broad shallow notch; lateral and inferior ridges broadly rounded; lateral angles prominent but low, very obtuse and somewhat jagged. Abdomen short and rather stubby. First tergite transverse, longer than usual, less than twice as wide as long in the middle, as wide as the base of the second segment; in outline cup-shaped with rounded anterior angles; its horizontal face in profile over half the length of the second tergite; its anterior slope forming a bluntly rounded right angle with the posterior, horizontal portion; its horizontal part distinctly wider in the middle than on the sides, without depression; the hind margin not thickened, simple. Second segment about as wide as long and almost parallel-sided; not contracted toward the base; moderately and about equally convex dorsally and ventrally; the apical margin simple, without raised or depressed lamella; the sternite gradually sloping basally, with a deep, median, longitudinal furrow near the base, the transverse basal furrow without longitudinal ridges, but separated from the articulation by a broad, smooth space; the surface of the tergite very slightly swollen on each side some distance from the apical margin. Legs very stout; tibiae much swollen, especially those of the hind legs; inner tooth of claw placed close to apex. Wings with the *Odynerus*-type of venation; radial cell rather shorter than usual, slightly and very gradually widened opposite the second cubital, broadly rounded at apex, without trace of appendiculate vein; third cubital higher than long.

Head mostly covered with an exceedingly fine, close and irregular puncturation, which gives it a dull, somewhat granular appearance; punctures more distinct on the cheeks; those of the clypeus larger (especially in the middle), much scattered, not separated by striae. Thorax with fairly uniform, medium-sized, moderately dense puncturation, which is very sparse below the humeral angles and on the ventral areas of the propodeum; tegulae, anterior and posterior (sloping) faces of mesopleura, and metapleura, impunctate, smooth. Concavity of propodeum impunctate, very finely and transversely striate in its lower half, almost smooth in its upper half. First tergite with fine, scattered punctures, which are very sparse in the middle, more abundant posteriorly, and much larger on the sides. On the second and succeeding tergites the puncturation is very fine, moderately dense, and fairly uniform; it is more distinct but sparser on the corresponding sternites. Body dull, especially the vertex and dorsum; clypeus and concavity of propodeum more shiny. Pilosity very sparse and short, brownish gray; the gula with longer, somewhat recurved hairs.

Ferruginous red (Ridgway's Sanford's brown); with inner margin and apex of mandible, a spot above the insertion of each antenna, a median dot on the frons, anterior sloping face of mesopleura, sutures of pleura and of scutellum and postscutellum, a median stripe in the upper half of the concavity of the propodeum, and extreme base of second tergite, brown to blackish; flagellum infusate above. The following parts are bright lemon-yellow (Ridgway's light cadmium): sides of clypeus; a wedge-shaped spot between the insertions of the antennae; a round, median spot below the anterior ocellus; inner orbits

(filling the sinuses of the eyes completely); most of the cheeks (connecting with the inner orbits and somewhat expanded over the vertex); under side of scape; much of the mandibles; a broad fascia on the anterior margin of the pronotum, continued narrowly on the sides to near the front coxae; four longitudinal stripes on the mesonotum (one pair very short, close to the tegulae; the other longer, curved, situated medially, not reaching the scutellum); most of the scutellum and post-scutellum; tegulae (except for a median ferruginous spot); most of the mesopleura; dorsal areas, lateral angles, and inferior ridges of the propodeum; a broad apical fascia on the first and second tergites and on the second sternite (that of the first tergite continuing along the sides to near the base; that of the second sternite connected with a median spot); much narrower apical fasciae on the third and fourth tergites and sternites, widened in the middle on the sternites; under side of the coxae and front and middle femora; tibiae entirely; and most of the tarsi. Wings subhyaline, strongly tinged with amber yellow throughout, very slightly purplish toward the apex; stigma and veins yellowish brown; costa and subcosta more ferruginous.

SANTO DOMINGO. Grande Anse, Haiti, one female, holotype (P. R. Uhler.—M. C. Z.).

Pachodynerus scrupeus* (Zavattari) var. *bahamensis, new variety.

Female.—Black. Most of the mandibles, labrum, apical margin of the clypeus, a line on the under side and extreme apex of the scape, second and third as well as under side of fourth antennal segments, a median spot on the tegulae, basal half of first abdominal tergite and sternite, last sternite, most of legs (including the coxae and excepting the yellow markings), ferruginous to reddish brown (Ridgway's burnt sienna to mahogany). The following parts are bright lemon-yellow (Ridgway's lemon chrome): a small triangular spot at the base of the mandible; basal two-thirds of the clypeus, deeply indented by a sagittate, median, black spot; a triangular spot in the lower part of the frons above the insertion of the antennae (not extending to the base of the clypeus); most of the scape; anterior half of the pronotum; most of the tegulae; posttegulae; two triangular, lateral spots on the scutellum; a broad fascia over the anterior half of the postscutellum; sides of propodeum (slightly less extensively than in typical *P. scrupeus*); upper plate of mesepisternum; broad apical margins on first tergite and second tergite and sternite (narrower than in the typical form and not invading the sides of the horizontal portion of the first tergite); under side and apex of front and middle femora; apex of hind femora; and outer side of tibiae. Wings as in the typical form.

BAHAMAS. Mangrove Cay, Andros Island, one female holotype, August 1, 1904 (M. C. Z.).

Pachodynerus (Pachodynerus) jamaicensis, new species.

Odynerus tibialis Fox, 1891, Trans. Amer. Ent. Soc., XVIII, p. 343 (♀). Ashmead, 1900, Trans. Ent. Soc. London, p. 312 (in part). Gowdey, 1926, Dept. Agric. Jamaica, Ent. Bull. 4, pts. 1-2, p. 95. Not *O. tibialis* H. de Saussure, 1852.
Odynerus guadulpensis Gowdey, 1926, Dept. Agric. Jamaica, Ent. Bull. 4, pts. 1-2, p. 95. Not *O. guadulpensis* H. de Saussure, 1852.

A medium-sized, stubby species. Black, with numerous lemon yellow markings on head and thorax, and yellow apical fasciae on the first two segments of the abdomen.

Length (h. + th. + t. 1 + 2); ♂, 7 to 8 mm.

Male.—Head, in front view, subcircular, about as high as wide; seen from above, transverse, about twice as wide as long, not wider than the thorax. Occipital margin with a distinct though shallow inward curve. Vertex and cheeks margined throughout by a sharp carina which is as high on the occiput as along the cheeks. Cheeks of moderate width, very slightly swollen in their upper half, where they are about half as wide as the upper part of the eye in profile; gradually narrowed in their lower half, the carina not forming an angle. Inner orbits about one and one-third times as far apart on the vertex as at the clypeus. Upper half of frons very little swollen. Ocelli in a flattened triangle; the posterior pair a little farther apart than their distance from the eyes, much farther from the occipital margin. Interocellar area with a distinct, longitudinal depression which, however, is not bordered by lateral swellings. Vertex without basin, fovea, or ridge. Antennae twice as far apart as their distance from the eyes, the ridge between them well developed, sharply carinate throughout. Clypeus irregularly hexagonal, slightly higher than its greatest width, which is a little below the middle, very slightly and uniformly convex throughout, with faint indications of two longitudinal swellings above the middle; its lower, free portion little shorter than the upper, interocular part; its truncate apex very broad, about one-third the maximum width of the clypeus, almost straight, the apical edges not projecting but forming sharp, somewhat ridged, right angles. Antenna short; flagellum slightly and very gradually swollen toward the apical third; scape short, less than one-third the length of the flagellum, slightly curved; third antennal segment about one and one-half times as long as the fourth; fourth to ninth longer than wide; tenth nearly square; eleventh slightly longer than wide at base, with the minute twelfth protruding from its truncate apex. Mandible much shorter than the length of the eye, straight; apex blunt and slightly curved; inner margin divided by four very shallow notches producing very broad, blunt teeth of unequal size: the first and third from the base extremely low, barely indicated, the second and fourth stronger and about equally prominent (although the second is a little sharper than the fourth, it is much wider at its base than it is high). Thorax stubby, barrel-shaped, very slightly and about equally narrowed anteriorly and posteriorly, a little longer than wide (the width is about equal to the distance between the anterior margin of the pronotum and the posterior margin of the scutellum), a little

wider than high. Pronotum moderately narrowed toward the anterior margin which is strongly curved inwardly and carinate throughout; the carina higher dorsally than on the sides, forming a low, translucent lamella which runs over the humeral angles; below the humeral angle the carina bifurcates, sending out a fine, sharp, not lamellate ridge to the hind margin of the pronotum; humeri forming right angles, but not pointed or projecting; the smooth anterior face without pits. Mesonotum slightly wider than long, almost regularly pentagonal in outline with broadly rounded anterior margin, moderately but decidedly convex, without notauli, with a fine, impressed, median line in the anterior third. Tegula much longer than wide, of normal shape, the outer and hind margins forming one continuous curve; posttegula narrow, short, straight, finger-shaped, with blunt apex. Scutellum rectangular, about twice as wide as long, moderately convex throughout, without tubercles, carinae, or impressions; the deep anterior and posterior sutures not foveolate. Postscutellum semi-elliptical with the anterior margin straight, about one-half the length of the scutellum; its anterior horizontal area about as long as the posterior, vertically sloping portion (part of the concavity of the propodeum); the passage between them rounded, without transverse ridge, superficially crenulate and without median depression; without tubercles. Mesepisternal suture continuous; epicnemial carina beginning at the mesepisternal suture and bifurcating in the lower half, the two branches (of which the anterior is the stronger) running across the sternum to meet their fellows from the other side. Lower edge of mesepimeron slightly produced downward into a short, blunt tooth; upper hind edge of metapleuron slightly raised into a low, triangular spine. Propodeum short, squarely and vertically truncate behind, moderately swollen on the sides; dorsal areas very broadly separated in the middle by the vertical face of the postscutellum; concavity wide and shallow, divided in its upper third by a fine, longitudinal carina which reaches the hind margin of the postscutellum, in its lower two-thirds with a median, flattened, smooth area; superior ridges raised into low but sharp, partly translucent lamellae which form a triangular, flattened, blunt tooth at each lateral angle, the ridges not curved inward behind the postscutellum from which they are separated by a broad depression but not by an abrupt notch; inferior ridges broadly rounded; lateral ridges bluntly angular but not carinate; lateral angles moderately produced, each bearing the lamellar tooth of the superior ridge. Abdomen short and very stubby. First tergite short and transverse, without median depression; in outline cup-shaped with rounded sides; a little more than twice as wide as long; its posterior, horizontal area in profile about half the length of the second tergite, forming a blunt, abrupt angle with the anterior, vertical area, the passage between the two areas distinctly swollen (with a slight median depression), although not forming a true ridge or suture; its hind margin not thickened, slightly produced in the middle, very narrowly translucent along the edge. Second tergite almost rectangular, distinctly wider than long, very little narrowed anteriorly where it is as wide as the apex of the first tergite, very slightly and evenly convex; the apical margin simple, flat, very narrowly translucent along the

extreme edge; second sternite in profile considerably depressed or slightly concave before the middle, angular anteriorly where it slopes vertically to the smooth, transverse, basal furrow and has no median, longitudinal furrow. Legs rather slender, of normal shape. Genitalia: shaft of penis slender in its apical fourth only, then rather rapidly widened to a very broad base; lobules long and narrow, broadly rounded apically and slightly produced into a basal angle (best seen in profile); margin of lobule simple, not denticulate; lobules fairly distant from the apophyses. Wing with the usual type of venation, very little different from that of *P. cubensis*, except that the third cubital cell is as high as long and about equally long on the radius and the cubitus.

Head and thorax densely and uniformly covered with coarse punctures which are finer on the cheeks and on the lower part of the face. Punctures of the clypeus, as seen with a hand-lens, very fine and sparse, scattered uniformly over the surface. Mandibles, tegulae, anterior and posterior faces of the mesopleura, and metapleura almost impunctate. Lateral areas of propodeum entirely covered with large, sparse punctures of unequal size; concavity in its upper third with large, irregular pits, in its lower two-thirds with heavy, transverse, slightly wavy ribs; dorsal areas subreticulate, with very heavy punctures. Much of the integument of the abdomen is either alutaceous or densely covered with microscopic punctures; in addition the dorsal surface has extremely sparse, fine punctures which are a little deeper and more numerous before the apex of the first and second tergites and even more numerous and coarser on the succeeding tergites; the horizontal area of the first tergite also bears coarse, scattered punctures which are denser on the sides and behind the basal, transverse swelling (this coarser puncturation of the first tergite is not present in the allied West Indian species *P. tibialis* and *P. guadulpensis*); sternites with scattered punctures, somewhat more numerous than on the tergites, the puncturation much coarser on the basal third of the second sternite. Head and thorax with short, sparse, erect, brownish gray hair; abdomen with very sparse, erect hair and short, appressed pubescence, blackish on part of the dorsal surface, finer and grayish ventrally.

Black. Most of mandibles, center of tegulae, extreme base of first abdominal segment, and legs (except coxae), pale ferruginous red; under side of flagellum somewhat ferruginous; legs somewhat blotched with dirty yellow, especially on the under side of the tibiae and toward the apex of the femora. The following markings are bright lemon yellow (Ridgway's lemon chrome): a large triangular spot at the base of the mandible; labrum; clypeus; a narrow streak along the lower inner orbits (barely entering the ocular sinuses); anterior face of scape; anterior half of pronotum; two spots on the tegula; posttegulae; anterior two-thirds or more of postscutellum; most of the upper plate of mesepisternum; a broad stripe on each side of the propodeum (covering most of the dorsal and lateral areas, but not entering the concavity); and a broad apical fascia on the first tergite and on the second tergite and sternite (that of the first tergite gradually widened toward the sides). Wings subhyaline, with an amber yellow tinge which is more pro-

nounced in the anterior half of the fore wing; radial cell slightly darker and somewhat purplish; veins and stigma yellowish brown.

Female.—Structure and sculpture of head, thorax, legs and wings as in the male, except for the following points. Cheeks relatively wider, almost two-thirds of the width of the upper part of the eye in profile. Inner orbits about one and one-fifth times as far apart on the vertex as at the clypeus. Upper half of frons distinctly swollen. Interocellar area very faintly depressed. Vertex with a small, transverse fovea. Clypeus broadly pyriform, about as wide as high, very slightly convex, somewhat flattened in the middle over its apical half (the flattened portion limited on each side by a very blunt, low ridge); its lower, free portion about as long as the upper, interocular part; its truncate apex about one-third of the maximum width of the clypeus, with a very shallow, inward curve, the sides forming bluntly rounded, right angles. Antenna short, especially the flagellum, the scape being over one-third the length of the flagellum; fourth and fifth antennal segments nearly square; sixth to eleventh increasingly wider than long; twelfth about as long as wide at base. Inner margin of mandible with four superficial notches producing very broad, low and blunt teeth. Punctuation of clypeus fine and rather dense on the sides and in the upper third, much coarser but sparser in the median, flattened portion. (Abdomen lacking).

Coloration of head, thorax, legs and wings similar to that of the male; but clypeus yellow in its upper half, black in its lower half, the truncate apical margin ferruginous red.

JAMAICA. Montego Bay, St. James, two males, holotype and paratype, December 30, 1919, and January 1, 1930 (A. M. N. H.). Kingston, one female, allotype, April, 1891 (W. J. Fox and C. W. Johnson.—A. N. S. Phila.). Portland, two male paratypes; St. Andrews, one male, paratype; Two Mile Wood, St. Catherine, November 14, 1919, one male, paratype; Bath, St. Thomas, February 2, 1920, one male, paratype (U. S. N. M.).

Mischocyttarus bruneri, new species.

A moderately slender species, more stubby than *M. cubensis* (H. de Saussure). Black, with the head, scape of antennae, dorsal face of thorax, and abdomen behind the first segment, reddish brown; no pale markings.

Length (h. + th. + t. 1 + 2): ♀ or ♂, 8 to 9 mm.

Female or Worker.—Head much swollen; seen from above, broadly rectangular and a little less than twice as wide as long; seen in front, about as high as wide. Vertex and cheeks not margined by a carina behind. Cheeks well developed, about as wide in profile as the eye or even a little wider; oculo-malar space long, nearly the length of the sixth antennal segment. Inner orbits as far apart on the vertex as at the clypeus. Ocelli small, in an equilateral triangle; the posterior

ocelli about as far from the inner orbits as from the occipital margin, but much nearer to each other. Clypeus much wider than long, trapezoidal, rather narrowly contiguous with the inner orbits over a distance about equal to the length of the oculo-malar space; its anterior margin somewhat more projecting than in *M. cubensis*, being divided by deep notches from the lateral lobes, which also are quite pronounced and somewhat angular; the apex itself bluntly rounded. Eyes bare. Antenna rather stubby; scape short, about three times as long as thick at apex, and about as long as the two following segments together; third segment slightly longer than the fourth and fifth together; flagellum somewhat more swollen in the apical half than in *M. cubensis*. Thorax with the usual shape and structure of the genus. Anterior margin of pronotum straight, very slightly raised, not carinate; humeral angles, as seen from above, broadly rounded and not in the least projecting. Mesepisternal suture well-marked. Propodeum with a rather narrow longitudinal groove. First abdominal segment much narrower than the remainder of the abdomen, forming a moderately long and slender petiole, which is decidedly shorter and more swollen than in *M. cubensis*; about two and one-half times as long as its greatest width (at apex), considerably shorter than the thorax, and only slightly longer than the second tergite; basal half parallel-sided; apical third, seen from above, about two and one-half times as wide as the base into which it passes quite gradually; spiracles not protuberant on the sides; in profile gradually swollen to its apical third, where it is about twice as thick as at the base. Remainder of the abdomen short, oval, conspicuously broader than the petiole. Legs long and stout; femora more swollen than in *M. cubensis*; tibiae slender at base, broad in the apical half; digitiform processes on the inner side of the third and fourth segments of the middle and hind tarsi moderately long, those of the fourth segment not reaching half the length of the fifth segment; claws of middle and hind legs subequal in each pair; middle tibiae with two spurs.

Under a hand-lens the body appears to be impunctate, except on the median, apical lobe of the clypeus and on the mandibles, which bear a number of coarse, scattered pits. Under the microscope, however, the entire body is minutely alutaceous, the very close, extremely fine sculpture giving it a somewhat dull appearance. Body very finely pubescent; apex of clypeus with a few longer and stouter hairs; propodeum and base of abdomen more densely clothed with silvery gray pile; tarsi more coarsely hairy; under side of hind tibiae toward the apex with a short brush of shiny, tawny pile.

Head entirely dull reddish brown (Ridgway's mahogany red), with a darker spot of dull black about the ocelli; mandibles and tip of clypeus rather lighter, bright red. Upper part of prothoracic lobes, mesonotum, more or less of the scutellum, sometimes the anterior margin of postscutellum, and more or less of the mesepisternum, dull red (Ridgway's burnt sienna); remainder of thorax dull black. First abdominal segment black, except for a narrow, dark brown, apical margin; remainder of abdomen reddish brown (Ridgway's chestnut), without markings of any kind. Scape and pedicel of antenna dull dark red; flagellum dull black, with a suggestion of red at the extreme tip.

Legs largely black; tarsi dull brown; extreme base of hind femora, an indistinct line on middle and hind tibiae, and fore part of front tibiae, reddish. Wings clear, amber-colored; second and third cubital cells almost hyaline; median cell and stigma darker.

CUBA. Sierra Maestra, at 4,500 ft., July 10-20, 1922, two females or workers, holotype and paratype (O. H. Ballou and S. C. Bruner.—U. S. N. M.).

***Polistes poeyi* Lepeletier var. *haitiensis*, new variety.**

Female and Worker.—Head reddish (Ridgway's chestnut), with the lower lateral margins and apex of the clypeus and the lower inner orbits (not entering the ocular sinuses) bright yellow (Ridgway's light cadmium). Vertex blackish about the ocelli; flagellum infusate beyond the third antennal segment. Thorax mostly black; only the posterior half of the scutellum and a spot on each side of the pronotum (covering most of the dorsal aspect), reddish; with numerous yellow markings as follows: narrow anterior and posterior margins of the pronotum; a spot on the mesepisternum beneath the base of the wing; coxal processes of meso- and metapleura; tegulae; anterior half of scutellum; most of postscutellum; a very wide longitudinal stripe on each side of the median groove of the propodeum; and articular valvulae of abdomen. Abdomen ferruginous (Ridgway's burnt sienna) to brownish black, the base of the first tergite sometimes black; with continuous bright yellow apical bands on the first to fourth tergites and on the second and third sternites; bands of first and second tergites widened on the sides where they are produced anteriorly; the bands as wide as in typical *P. poeyi*. Coxae and most of femora black; femora brownish red in the apical half (especially above) and with an apical yellow spot (larger on the front and middle legs); tibiae reddish to brown on the inner side, extensively yellow on the outer side; tarsi yellow, the terminal segments mostly reddish on the middle and hind legs. Wings moderately infusate, with a ferruginous tinge which is more pronounced than in typical *P. poeyi*.

Male.—Coloration similar to that of the female and worker, but mandibles mostly and inner orbits more extensively yellow (this color covers the lower half of the ocular sinuses); fourth abdominal sternite also and fifth tergite occasionally with an apical yellow band; front and middle coxae with a yellow spot on the under side; front and middle femora extensively yellow beneath; tarsi almost wholly yellow.

A careful study of the structural characters discloses no differences from the typical color phase of *P. poeyi* Lepeletier, of Cuba, a species which has thus far been called *P. minor*. The true *P. minor* P. de Beauvois (*P. hertwigi* Schulz) is, in our opinion, restricted to Santo Domingo, while *P. poeyi* occurs in both islands, though in distinct color phases.

SANTO DOMINGO. Bizeton, Haiti, January 9, 1922, one female or worker, holotype (A. M. N. H.). Haiti, without more

definite locality, March, 1925, one male, allotype (G. S. Miller.—U. S. N. M.). Azua, Rep. Dominicana, March, 1913, one female or worker, paratype (P. G. Russell.—U. S. N. M.). Port-au-Prince, Haiti, one male, paratype; Carrefour, Haiti, one worker or female, paratype; Fond Parisien, Haiti, one worker or female, paratype; Sanchez, Rep. Dominicana, one female or worker, paratype (A. M. N. H.).

***Polistes crinitus* (Felton) var. *insulicola*, new variety.**

Polistes crinitus J. C. Hutson, 1918, West Indian Bull., Barbados, XVI, 4, p. 322. Not of Felton, 1765.

Female and Worker.—Head mostly reddish brown (Ridgway's burnt sienna); blotches behind the ocelli, narrow occipital and hind margins of cheeks, middle of flagellum (from the middle of the third antennal segment to the base of the eighth), black; narrow apical margin of clypeus and apical teeth of mandibles, brownish black. Thorax and legs mainly black, without reddish markings. Abdomen mostly reddish brown; basal two-thirds of first tergite and extreme base of second segment black. The following areas are yellow (Ridgway's light cadmium): narrow preapical portion of clypeus; a broad band on the vertex (behind the ocelli), continued over the upper two-thirds of the cheeks (along the outer orbits); most of the mandibles; narrow anterior and posterior margins of pronotum; tegulae; anterior half of scutellum and postscutellum; apical valvules of propodeum; middle and hind coxal processes; a spot on the upper plate of the mesepisternum (beneath the base of the fore wing); all the tarsi; all the front and middle tibiae; basal half of hind tibiae; broad apices of all femora; and apical fasciae of moderate and somewhat variable width on the first three, four or five tergites and on the second or second and third sternites. Wings, stigma and veins bright ferruginous yellow.

ST. KITTS (or St. Christopher). Several female or worker paratypes, without more definite locality (N. Y. Ac. Sci.) (H. A. Ballou.—B. M.). Basseterre, one female holotype and several female or worker paratypes, March 26, 1927 (Corn. Univ.).—NEVIS. One worker paratype (H. A. Ballou).—ST. CROIX. Christiansted, several female or worker paratypes, April, May and June (N. Y. Ac. Sci.). Fredericksted, several female and worker paratypes, March 25, 1927 (Corn. Univ.).

***Polistes bahamensis*, new species.**

A medium-sized, slender species, with the abdomen elongate fusiform, much pointed and compressed laterally at apex. Differing from *P. crinitus* (Felton) and *P. minor* Palisot de

Beauvois mainly in the shape of the head of the female and in the clypeus of the male.

Length (h. + th. + t. 1 + 2): ♀ and ♂, 10 to 13 mm.; ♂, 11 to 13 mm.

Female and Worker.—Head larger than usual; seen from above, transverse, about twice as wide as long, moderately swollen behind the eyes, the cheeks about as bulging as and a little shorter than the upper part of the eye; in front view, distinctly wider than high. Vertex and cheeks separated from the occiput by a fine carina which does not reach the base of the mandibles; lower third of cheeks separated from the gula only by a bluntly rounded edge. Cheeks, in profile, very wide, distinctly widest at the lower third, where they are about as wide as the eye. Oculo-malar space moderately long, in front view nearly one-sixth of the length of the eye. Inner orbits about as far apart on the vertex as at the clypeus. Ocelli in an equilateral triangle; the posterior pair a little closer to the occipital margin than to the eyes, about twice as far from the eyes as from each other. Interocellar area slightly raised transversely behind the anterior ocellus. Antennae slightly less than twice as far from the eyes as from each other; frons between them not carinate, but raised into a low, broad tubercle. Clypeus cordiform in outline, moderately and uniformly convex throughout, distinctly wider than high; upper lateral margins contiguous to the eyes for a distance about equal to the length of the oculo-malar space; lower lateral margins converging to form a very obtuse angle at the bluntly rounded apex; lower, subocular portion of the clypeus about as long as the upper, interocular part. Eyes bare. Antenna rather slender, exactly as in *P. crinitus*. Thorax, abdomen, and legs as in *P. crinitus*.

Sculpture as in *P. crinitus*.

Male.—Structurally like the female and worker, except for the following points. Cheeks much shorter and less bulging on the head seen from above, much narrower in profile (about half as wide as the eye), although distinctly wider than in the male of *P. crinitus*. Eyes as bulging as in the male of *P. crinitus*. Oculo-malar space not much shorter than in the female. Interantennal tubercle very protuberant. Inner orbits about one and one-sixth times as far apart on the vertex as at the clypeus. Clypeus not flattened but very slightly and uniformly convex, without longitudinal depressions, pentagonal or subcordate in outline, slightly wider than high; its upper lateral margins contiguous to the eyes for about one-fourth of the length of the clypeus (less than the length of the oculo-malar space); its anterior margin distinctly projecting, although evenly rounded off; its lower, subocular portion about as long as the upper, interocular part (in general shape the clypeus is much more like that of the female than is the case in *P. crinitus* and *P. minor*). Antenna much as in *P. crinitus*, but the median segments of the flagellum rather thickened; thirteenth segment one and one-half times as long as the twelfth. Seventh sternite as in *P. minor*, without median tubercle, deeply grooved in the middle, with a depressed

apical area, the strongly raised lateral slopes projecting on the sides in profile. Genitalia more like those of *P. minor*, with an elongate elliptical spoon at the apex of the penis. Clypeus and mandibles with few, very scattered, large punctures.

P. bahamensis occurs in the Bahamas in several color phases. We have seen three of these, each of them known from one of the islands only. We are giving them distinct names mainly in order to call attention to this peculiar geographical segregation. It will be extremely interesting to follow further investigations of the wasp faunae of the many other islands that form the Bahama group. The three color phases known to us may be separated as follows:

1. Head and thorax black and ferruginous, marked with yellow; mesonotum entirely ferruginous, usually without yellow lines (rarely with traces). Abdomen ferruginous red, with black base; as a rule only the first tergite with a broad, yellow fascia; rarely the second also very narrowly yellow at apex. typical *bahamensis* Bequaert and Salt.
- Head and thorax mostly black, with a few ferruginous blotches and numerous yellow markings; mesonotum with two longitudinal, yellow lines or stripes. Abdomen ferruginous red with black base; all the segments with apical, yellow fasciae. 2.
2. Yellow markings of moderate extent; mesonotum and propodeum with two narrow, short lines; face partly reddish brown; apical fasciae of abdominal segments narrow. var. *bilineolatus* Bequaert and Salt.
- Yellow markings very extensive; mesonotum with four wide, longitudinal stripes; propodeum very extensively yellow; face almost wholly yellow; apical fasciae of abdominal segments broad. var. *picturatus* Bequaert and Salt.

***Polistes bahamensis*, typical form.**

Female and Worker.—Head mostly reddish brown (Ridgway's burnt sienna); occiput, blotches about the ocelli, upper side of scape and middle of flagellum above, brownish black to black. Thorax and legs mainly black; upper side of pronotum, most of mesonotum, and posterior half of scutellum, ferruginous red (Ridgway's Sanford's brown); tibial spurs ferruginous brown. Abdomen bright ferruginous red (Ridgway's Sanford's brown); basal half of first segment and extreme base of second, brownish black to black. Pale yellow markings of moderate extent (nearest to Ridgway's light cadmium), as follows: clypeus (except for a median rufous spot); broad inner orbits, filling the whole ocular sinuses and extending very narrowly above them; nearly the whole cheeks and oculo-malar spaces, extending over the vertex where they are very narrowly divided in the middle; most of mandible; tip of antenna (more orange); narrow front margin and very narrow hind margin of pronotum; sometimes traces of two very narrow, median lines on mesonotum; tegulae; anterior half of scutellum and postscutellum; a large spot on upper plate of mesepisternum; two fairly broad longitudinal lines on the middle of propodeum (on either side of the groove); lateral valvules of abdominal articulation; sometimes a small spot on each side of propodeum and on middle and hind coxal

processes; all tarsi; front tibiae; most of middle tibiae (black above in the apical half); basal third of hind tibiae; broad apices of all femora; a medium-sized apical fascia on first abdominal tergite; and sometimes a very narrow apical fascia on second tergite and at the sides of second sternite. Wings strongly suffused with amber to golden yellow, rufous along the costal margin and in the stigma of the fore wings; radial cell more or less purplish; veins rufous.

Male.—Coloration very similar to that of the female and worker, but the yellow markings somewhat more extensive: lower two-thirds of the face yellow; under side of the scape yellow; flagellum more orange than ferruginous on the under side; yellow spots on the under side of middle coxae and the under side of front coxae, as well as prosternum, mostly of that color; under side of front femora extensively yellow, suffused with rufous.

BAHAMAS. Mangrove Cay, Andros Island, female holotype and thirteen female paratypes, May and June, 1904 (W. M. Wheeler.—A. M. N. H.); male allotype, ten male paratypes and thirty-four female paratypes, August, 1904 (Allen, Barbour and Bryant.—M. C. Z.); four female paratypes, June 24, 1924 (C. E. Olsen).

***Polistes bahamensis* var. *bilineolatus*, new variety.**

Female and Worker.—Head mostly reddish brown (Ridgway's burnt sienna); most of vertex, occiput, broad occipital margins, upper side of scape, and middle of flagellum above, black. Thorax and legs mainly black; an obscure spot on each side of pronotum and two longitudinal blotches on mesonotum, rufous; sometimes postscutellum and propodeum partly rufous; tibial spurs ferruginous brown. Abdomen bright ferruginous red (nearest to Ridgway's Sanford's brown); as a rule only basal half of first segment black; sometimes also extreme base of second segment dark brown to black. Pale markings very numerous, varying from bright yellow (Ridgway's light cadmium) to a more creamy color (Ridgway's pinard yellow), as follows: two lateral stripes over the clypeus or most of the clypeus except for a median spot; very wide inner orbits, filling the whole ocular sinuses but not extending above them; most of the cheeks, including the oculo-malar spaces and narrowly extending across the vertex where they are divided by a black spot; most of the mandibles; narrow front and hind margins of pronotum; tegulae; two longitudinal lines over mesonotum, placed in the rufous blotches and rather variable in size and extent; two transverse spots on anterior half of scutellum, sometimes connected in the middle; a narrow, transverse band on anterior half of postscutellum, rarely interrupted in the middle; a large spot on upper plate of mesepisternum; two narrow, longitudinal lines on middle of propodeum (on either side of the groove); lateral valvules of abdominal articulation; sometimes a small spot on each side of propodeum and on middle and hind coxal processes; all tarsi; most of front tibiae (often more or less rufous); basal third or

fourth of middle and hind tibiae, the yellow extending to the apex on the under side of the middle tibiae; broad apices of all femora; regular, medium-sized fasciae at apical margins of first to fifth abdominal tergites (continuing along the sides of the anterior tergites) and of second to fifth sternites; a small spot on each side of sixth tergite; and a large blotch on sixth sternite. Wings strongly suffused with amber to golden yellow, rufous along the costal margin and in the stigma of the fore wings.

BAHAMAS. New Providence Island, female holotype and thirteen female paratypes, November, 1912 (A. M. N. H.); four female paratypes (M. C. Z.); three female paratypes, December, 1912 (U. S. N. M.). Nassau, New Providence, two female paratypes (W. M. Wheeler.—A. M. N. H.); one female paratype, February, 1915 (H. G. Dyar.—U. S. N. M.). Blue Hills, Nassau, New Providence, seven female paratypes, January, 1909 (W. W. Worthington.—C. M.).

***Polistes bahamensis* var. *picturatus*, new variety.**

Female and Worker.—Head mostly yellow (Ridgway's light cadmium); vertex black across the ocelli; occiput black; interantennal area down to the clypeus ferruginous red; antenna mostly ferruginous, the apex more orange, the upper side of the scape and of the median segments of the flagellum blackish. Thorax and legs mainly black; a spot on each side of pronotum and extensive areas of mesonotum ferruginous red; tibial spurs ferruginous brown. Abdomen mostly bright ferruginous red (Ridgway's Sanford's brown); basal half of first segment and extreme base of second brownish black to black. The yellow (Ridgway's light cadmium) markings of thorax, legs and abdomen are very extensive as follows: broad front and hind margins of pronotum, their connections forming large, triangular spots in the anterior half; four broad, longitudinal stripes on mesonotum, the two median ones not reaching the front and hind margins, the two lateral ones much shorter and placed close to the tegulae; tegulae; more than the anterior half of scutellum and postscutellum; a large spot on the upper plate and a much smaller one on the lower plate of mesepisternum; most of propodeum, leaving the median groove black and a black spot on each side behind the postscutellum; valvules of articulation of abdomen; minute spots on middle and hind coxal processes; all tarsi; front and middle tibiae; basal half of hind tibiae; broad apices of all femora; large spots on under side of front coxae; and broad apical fasciae on all abdominal tergites (more or less continued along the sides; that of the first abruptly emarginate by a rectangular, rufous, median spot) and on second to sixth sternites. Wings as in the typical form.

BAHAMAS. Gold Rock, Acklin Island, female holotype, March 6, 1909 (W. W. Worthington.—C. M.).

THE NEUROPTERA OF HAITI, WEST INDIES.¹

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An excellent opportunity to collect and study the Neuroptera of Haiti came to the writer while he was in the employ of the Service Technique between July 15, 1928 and March 20, 1930. While this work was not a major enterprise, nevertheless a fair representation of this order has been brought together. Some of the insects, notably the Chrysopidæ and several Myrmeleontids², were found to be common insects there.

There are no published papers dealing with the Neuroptera of either Haiti or Santo Domingo but several species from Hispaniola, belonging in this order, have been described in taxonomic papers. Navas, who is a prolific writer on Neuroptera, has published papers containing many genera and species from the neighboring countries particularly from Cuba, Central America, and South America. Not all of these papers were available to the writer, but Professor Nathan Banks very kindly determined the species which are included in this paper. The writer was privileged to study the Neuroptera collections in the Museum of Comparative Zoology at Cambridge, Massachusetts during the summer of 1927³. The emphasis, while there, was placed on the Chrysopidæ, but the collection of Neuroptera from tropical America was also studied.

Representatives of all of the species of this collection of Haitian Neuroptera and the types of new species upon which this paper is based have been sent to Professor Nathan Banks for checking up and criticism of the writer's determinations and for final deposition in the Museum of Comparative Zoology, Cambridge, Massachusetts. The writer alone is to be held responsible for any mistaken identifications of this material or synonyms which may be discovered later. Sincere thanks and

¹Contribution No. 387, from the Department of Entomology, Kansas State Agricultural College.

²The spelling of family names as in Tillyard, *Insects of Australia and New Zealand*, 1926, is being used.

³Acknowledgment is made to Bache grant No. 286 for carrying on this study of types. Some of the illustrations for this paper were made with this grant.

acknowledgment is expressed to Professor Banks for this and much past aid. Some paratypes or duplicates have been sent to the Department of Entomology, Service Technique, Port au Prince, Haiti, and some have been retained by the writer.

GENERAL TOPOGRAPHIC FEATURES OF HAITI.

A brief summary of the geography and climate of Haiti was given by Smith and Audant (1930). The greater part of these specimens came from the region around the Agricultural college at Damien which is located on the Cul de Sac plain five miles northeast of Port au Prince and about a mile from the sea. This area is a broad level plain bounded on the north and south by mountains 1000 to 3500 feet high and extending east to the salt lakes. There are sugar cane and cotton fields in the western parts around the college and where irrigation water is available but elsewhere the land is grown up with mesquite, cactus and masses of tropical vegetation, making it impenetrable except along trails and roads.

There is a sisal and cotton experimental farm of about 400 acres at Hatte Lathan about 3 miles farther northwest from the college along the road to St. Marc where some of the specimens were collected. Other specimens were collected at electric lights on porches in Port au Prince and at Petionville, which is a small village about 2 miles east of Port au Prince on the side of a mountain at an altitude of about 1500 feet. Other specimens came from Kenscoff about 7 miles still further up on the mountain and at an altitude of about 3000 to 3500 feet.

Cotton, citrus trees, several gaiac (guyac) trees, mango trees, rose bushes, and sorghums yielded Chrysopid larvæ and adults in fair numbers. The best collecting period extends from about October to March.

LIST OF KNOWN SPECIES OF NEUROPTERA FROM HAITI BY FAMILIES.

No representatives of the Sialidæ, Raphidiidæ, Mantispidæ nor of the lesser families of Hemerobiids were collected during this period. No representatives of these groups have been reported, to the writer's knowledge, for Haiti or Santo Domingo.

Hemerobiidæ.

The Hemerobiids are rare in Haiti, only three specimens having been brought back.

***Nusalala damiensis* n. sp.**

A small slender species without prominent markings but which can be identified by the blackish-brown line along the outer gradates of both wings nearly parallel with the wing margin and the swollen flattened second and third tibiae.

Head brownish-black; front and clypeus naked, but vertex and occiput sparsely covered with conspicuous brown setae. Antennae uniformly light brownish, thickly covered with short brown setae, reaches to about the middle of the folded wings; basal segment marked with black. Palpi uniformly amber.

Body dark shining brown, sparsely covered with short gray pile. Prothorax sparsely beset with brown setae with gray tips.

Front wings as indicated in Pl. II, Fig. 12, with 3 series of gradate veinlets, outer series of 7, middle series of 2 (to M) and an inner series of 4. Most of veinlets with light portion in middle, outer series dark brownish forming a conspicuous dark brown line parallel with the margin of the wing. Five radial sectors. Recurrent vein forked with an anterior branch to the margin. A conspicuous black spot on Cu just basad of the fork of Cu.

Hind wings with 2 series of gradates, an outer conspicuously dark brown one, parallel to the margin of 6 veinlets and inner one of 4 (to M); the lower veinlet lighter in color; 4 radial branches.

Legs uniformly light amber, sparsely beset with light brown setae. Front tibiae only slightly swollen beyond the middle, but middle and hind tibiae are markedly swollen and flattened, and the hind tibiae are slightly curved.

Described from a single specimen, a female, collected on cotton by André Audant, May 12, 1929. Total length 9 mm. Length of front wings, 8 mm. Width of front wing, 3.5 mm. Length of hind wing, 7 mm. Width of hind wing, 3 mm.

Type in Museum of Comparative Zoology.

***Micromus haitiensis* n. sp.**

A slender winged species with light wing and body coloration and without conspicuous dark spotting.

Face elongate, light brownish, marked with darker brown areas and with two triangular ocherous areas below the antennae. Four pairs of long gray setae on the clypeus, two pairs at the upper margin and two

pairs on the lower. Palpi uniformly light brownish, very sparsely set with colorless setae. Mandibles shining black, antennae light amber closely beset with light brownish setae, vertex and occiput yellowish-brown, carinate, sparsely beset with short gray setae.

Body brown, covered with gray pile. Prothorax light brown, marked with dark brown, sparsely beset with gray setae. Legs entirely amber, sparsely covered with light brownish setae. Femora approximately equal in diameter throughout, no prominent expansions. Abdomen light brownish, bearing prominent brown setae with gray tips on the distal and ventral portions.

Wings as illustrated in Pl. II, Fig. 10. Front wings without recurrent vein; with 2 series of gradates, an inner and outer series of 4 (to Media) veinlets each. The first three of outer series are dark brown, fourth lighter brown, distad of others. Four sectoral branches. Hind wings with 2 somewhat irregular gradate series of 2 (or 3) and 3 each, without prominent markings. Costal wing area very narrow before the stigma.

Front wing, 7 by 2.5 mm. Head to tip of wings, 7.5 mm.

Type, a female, collected at lights in Petionville, near Port au Prince, by Dr. H. L. Dozier, February 17, 1930. In Museum of Comparative Zoology.

A paratype collected on cotton by André Audant, February 9, 1929 in which the darker brown areas are reddish brown, otherwise like the type.

***Megalomus lioni* Navas.**

This has been described from Port au Prince, Haiti. (Navas: *Insectos del Museo de Paris 4ª Serie*. Broteria, 1927, Vol. 24, Fasc 1, p. 26-27). No representatives of this species have been seen by the writer.

CHRYSOPIDÆ.

Haiti has a relatively large number of species of Chrysopidæ. They are at times fairly plentiful in cotton fields and on certain trees when infested with aphids, mealy bugs or white flies.

KEY TO THE GENERA OF HAITIAN CHRYSOPIDÆ.

- A. Median loop of front wings (M3 plus 4) extending in a gentle curve, enclosing an elongate oval cell, (Fig. 11)..... **Chrysopa** Leach
- AA. Median loop angulate, enclosing a larger, angulate cell, (Fig. 20),
Leucochrysa Banks

KEY TO THE SPECIES OF CHRYSOPA OF HAITI.

- A. Basal segment of antenna with one or two brownish-red or red longitudinal bands on the upper side, only rarely much faded.
- B. Basal third or fourth of antennae beyond segment one, is black. *haitiensis*
- BB. Basal portion of antennae not black but uniformly yellowish or covered with small brownish setae.
 - C. A definite reddish line each side of pronotum. No brown spots on the mesoscutum, inner series of gradates of only one to three reddish-brown veins. *damiensis*
 - CC. No definite reddish line on each side of the pronotum; but sides are lightly suffused with reddish; a prominent purplish spot or diffused brown on each mesoscutal lobe, inner series of gradates of about four black veins. *freemani*
- AA. No red longitudinal bands on basal segments of antennae.
 - B. Pronotum with a definite red or reddish band along each lateral margin. *antillana*
 - BB. Pronotum without definite red bands along each lateral margin, but a faint reddish suffusion may occur which is indefinite as to outline.
 - C. Genae without a prominent, definite red band from eye to mouth.
 - D. Meso- and metanotum yellowish red on the sides, palpi yellowish brown, last segment elongate, dark. *lioni*^{*}
 - DD. No reddish or brownish markings on sides of the thorax, last segment of palpi not especially elongate, brownish or blackish; no black line on segments.
 - E. A green, generally robust, species with pronounced ivory dorsal band on body, face with some suffusion of reddish, basal cross vein of inner series parallel or almost parallel to rest. *thoracica*
 - EE. A very pallid or yellowish species, face wholly yellow and in some pinned specimens, entire head is brown or reddish brown; no dorsal median ivory stripe on thorax, inner series of gradate veinlets usually only two or three brown veins, the basal one not parallel to the others. *wolcottii*
 - CC. Genae with a definite band from the eyes to the mouth of some shade of red, or the reddish may be indefinite if there is a pair of red comma-shaped spots on the vertex.
 - D. Gradates and many other cross veins dark brown or black; palpi with a narrow brown or black line on outside. No reddish suffusion on sides of pronotum.
 - E. A pair of definite red marks on the vertex in the form of commas or parentheses, less commonly a reddish suffusion on the vertex. Gradates and most other veins wholly or in part black. *dozieri*
 - EE. No reddish comma or V-shaped marks on the vertex and the red spots next to the compound eyes are either absent or greatly reduced. A yellowish or very light median dorsal band. *estrada*
 - DD. Wings with all veins entirely green or only a few cross veins brownish green; at least with not very dark venation. Palpi with a broad black or dark brown line outside so that segments appear brownish or dark. Sides of pronotum suffused with reddish. *exterior*

^{*}This species has not been seen by the writer.

***Chrysopa damiensis* n. sp.**

A small, very common species in the lowlands of Haiti recognized by absence of genal spots, single longitudinal reddish band on the upper side of the basal segments of the antennae, by the broad reddish band along the margins of the pronotum and by the dark brown cross veins in the wings, the front wings in particular.

Vertex yellowish green, without marks; front ivory; clypeus and labrum brownish, genae without bands, palpi broadly banded with brown, end segments nearly wholly brown. Basal segment of antenna with a broad, red band on upper side, most distinct on distal part of segment, fading basally; second segment somewhat reddish at end of red band; remainder of antennae pale yellowish except end segments, which are somewhat brownish. Antenna reaches nearly to the tip of the wings.

Pronotum with a broad, faded, salmon red longitudinal band along each lateral border, the band arising between the vertex and the anterior pronotal angles and broadening to the transverse suture, beyond which the band is narrower and less distinct. Sides of pronotum sparsely beset with fairly conspicuous colorless hair. Rest of thorax and abdomen pale yellowish green (in death). Sides and tip of abdomen with colorless hair as on the thorax.

Front wings (Figure 11) with practically all cross veins nearly or completely brown, the venation is therefore conspicuously dark; stigmas obscure, slightly greenish. Two series of gradates, 5 (outer) 2 and 3 inner, the veinlets light at ends, brown in the middle. Hind wings with less brown venation, gradate series 4 and 1, veins light brown except at ends. Venation as shown in Figure 11. Apices of wings angular.

Venter of body lighter yellowish-green than the dorsum. Legs very pale, thinly covered with short black setae.

Type, a male, reared by the writer from a larva collected at Hatte Lathan, Haiti, January 18, 1929. Total length 12 mm., length, front wings, 9.5 mm., width, 3.5 mm. In Museum of Comparative Zoology.

There is the usual range of variations in the series of about 50 paratypes.

The total length varies from 10 to 14.5 mm. The reddish borders of the pronotum vary from broad dark red bands to short, faint salmon bands. In some specimens there is a narrow green border between the bands and the extreme outer border of the pronotum. The antennal bands are generally red but they vary particularly in length. The venation of the front wings is not always as dark as the type. There is

some variation in the number of the gradate veinlets. The front wing series varies from 4-1 in the small specimens to 6-3 in the larger ones. In the hind wings the range is from 4-1 in small specimens to 6-3 in the larger ones.

This is the most abundant species of Chrysopid on the lowlands around Port au Prince. It occurs on cotton primarily being most plentiful from December to May but is present all year. It is similar to *C. villosula* Navas of Cuba but according to Banks, that species has two stripes on the basal segments of the antennæ.

The species name refers to Damien where the headquarters of the Service Technique and the Entomological Department are now located

Life History and Stages.—The eggs are deposited singly and stalked, and are light yellowish-green in color. They hatch in 4 days; 1st. instar 2 or 3 days; 2nd. instar 3 to 5 days; 3rd. instar 3 to 6 days. Larval life, average of 5 cases, 11.3 days. Pupal stage 14 to 22 days.

The larva is a trash carrier (Fig. 1), and therefore has the body contour, long stalked thoracic tubercles and small microscopic hooked setæ on the dorsum of the abdomen which is characteristic of trash carriers. General color of the body is gray, marked with brownish-black. Head with two pairs of black marks, the median pair connected posteriorly forming a loop. Body darker than most trash carriers and with more black marks along the segments and the dorsal vessel than is usual.

In addition to cotton, it has also been taken on papaya, artichoke, "pois maldioc" and cow peas. It was reared by feeding on cotton and feterita aphids and on the black aleyrodid on citrus.

***Chrysopa exterior* Navas.**

NAVAS: Ann. Soc. Scient. Bruxelles, 1922, p. 170. (*externa*).

NAVAS: Mem. R. Acad. Cienc. Barcelona, 19, No. 5, 1925, p. 12. (*exterior*).

Similar to *C. harrisii* of the U. S., to *dozeri* of Haiti and *estradaei* Navas of Cuba. The identity of these specimens was determined by Professor Banks. It may be recognized by the sides of pronotum being darker green, generally suffused with red, no dorsal yellow or ivory band and genæ not suffused with red but with a clean cut red band.

Inasmuch as the original descriptions of the Neuroptera species of Navas included herewith are very brief and have been published in journals not available to most American workers, it has been thought advisable to include somewhat detailed re-descriptions of those species in this paper.

Head light yellowish, almost without any greenish tinge. A definite red band from eye to mouth on the genae. Palpi brownish with last segments distinctly brown. Antennae long, reaching nearly to tips of wings. Basal segment yellowish without markings or setae. Remaining segments appear brownish because of the short brown setae, but the ground color is light yellow. Vertex light yellow, a pair of red spots next to the compound eyes.

Pronotum yellow, but without definite median yellowish band, covered sparsely with gray setae; margins darker green, with a reddish tinge particularly at the anterior angles. This marking is specific. Rest of body yellowish and without markings.

Abdomen with gray setae on the lower part. Legs light yellowish, sparsely beset with short brown setae.

Wings with all veins yellowish green, median loop fuses well before the cross vein in front wing. An outer series of gradates of 7 green veins and an inner series of 5, the outer series less than twice the length of the middle veins from the margin; the inner series near the middle of the sectoral area. Outer series in hind wings of 6 veins and inner series of 5. Stigmas not apparent. Tips of wings sharply angulate. Total length, 14 mm., length of front wing, 11 mm., width, 4 mm.

A large series of specimens collected around Damien, October to April, on sorghum, feterita and cotton. Many of the adults were reared. Specimens differ in the amount of green and yellow on the body some appearing distinctly light greenish. The pronotal lateral markings in some specimens are more distinctly reddish. This marking is lateral and not suggestive of the bands which occur in *haitiensis*. Some specimens show a few dark veins in the anal region of the wings. Banks informed the writer of the identity of this species and pointed out that Navas had originally described this species as *externa* but this name having been used by Hagen (1861) and according to Navas, by Petersen for a species from Australia, Navas indicated (1925) the name *exterior* for the Species.

Typical Life Histories.—Eggs December 19; hatched December 23; spun January 5; emerged January 16. Eggs February 23; hatched February 26; spun March 8, emerged March 21. Larva of the type of *C. plorabunda*; (Fig. 2), not a trash carrier. Head yellowish with two black longitudinal bands and with a short narrow single median one. This is a distinct recognition

character. Median portion of body reddish brown, with light yellowish border. Tubercles all yellow, bearing white setæ. Legs smoky.

Chrysopa haitiensis n. sp.

This species differs from *C. lateralis* of Florida in that the dark red or maroon band on the basal segment of the antenna of the Haitian specimen is narrower, of more nearly uniform width, darker red in color and is located more nearly in the middle of the upper side of the segment instead of at the outer margin; the genitalia in the type are tinged with brown; the pronotum is broader than in Florida specimens and slightly longer and the general body color is a little darker green. The species is also similar to *C. epheba* Navas according to Banks.

Head uniformly yellowish, no genal nor vertical marks. Palpi uniformly light brownish. Basal fourth of antennae blackish, lighter beyond; basal segment of antenna with dark red band on upper side as described above.

Pronotum about as broad as long, sides parallel, without lighter median band, sides of pronotum red, the red beginning at the extreme lateral margins. Rest of thorax yellowish green. Abdomen darker green on dorsum with yellowish-green sides and venter. Tips of genitalic processes dark brown. Genitalia open, the upper and lower plates appearing in side view like the mandibles of some reptiles. Legs uniformly yellowish green, tarsi light brownish.

Wings with longitudinal veins green. Outer series of gradates in front wings of 6 veinlets, brown in middle, inner series of 3, also brown in middle; inner series close to outer, being only about twice their length apart, basal veinlet of inner series not parallel to the others. First 9 cross veins between R and Rs brown in middle, the one based being darkest brown and the rest becoming progressively lighter in color. Cross veins between pseudo-media and cubitus brown in middle, anal and cubital branches at margin brown except at ends. Median loop ends beyond the cross vein, enclosing a very narrow elongate cell. Hind wings with two series of gradates, 7 and 2, close to each other. All cross veins appear green or a few with only tinges of brown near the middle. Stigmas yellowish green, fairly prominent.

Length of head to tip of folded wings, 15 mm., width of front wing, 4 mm.

Type, a male, reared from a larva collected on a citrus tree at Petionville, December 22, 1928.

The seven paratypes show a variation in the shape of the pronotum, some specimens having a longer, narrower pronotum than the type. Some specimens have the gradates and other

cross veins in the basal part of the wings dark reddish brown except for short light areas at the ends. Collected by beating a gaiac tree at Hatte Lathan, in January and February.

Larva a trash carrier, superficially resembling the larva of *C. lateralis*. Only one was seen. It had two pairs of converging, brown dorsal bands on the head, tips of tarsi black.

***Chrysopa thoracica* Walker.**

WALKER: Catalogue Specimens Neuroptera, Brit. Mus., 1852, p. 243. St. Domingo.

One of the larger and more robust species of *Chrysopa* in Haiti identified by Banks. A fine series of 31 specimens taken most of which faded badly. Recognizable by the dark green body coloration, broad short pronotum with yellow dorsal band, yellowish antennæ and nearly wholly green venation.

Head yellow, clypeus heavily suffused with red, forming a fairly definite red bar, though this may be a secondary feature. A narrow somewhat indefinite reddish bar under each antenna on the front. No red marks on the genæ. Vertex with two somewhat indefinitely outlined red spots forming an indefinite V pattern. Palpi uniformly light reddish brown. Antennæ wholly yellowish, without any markings, reaching to near the tip of the folded wings. Body with narrow, ivory or yellowish dorsal band, most definite over the thorax and a little less definite over the abdomen. Prothorax nearly as broad as the head, including the compound eyes, making this region unusually broad. Body with a narrow ivory median band and blackish-green borders.

Wings fairly broad and somewhat angular. Front wings with two series of gradates, 8 and 4 veinlets; gradates and at least part of most other cross veins in the basal half of the wing blackish. Fusion on M^{3+4} well beyond the cross vein. Hind wings with two series of gradates 6 and 4, only slightly brown. Stigmas yellowish, obscure. Legs uniformly yellowish, tarsi light brownish.

Length, 16 mm. Length of front wings, 13 mm.; width, 5 mm.

Specimens vary greatly in the amount of red present and in the general body coloration. The reddish suffusion on the vertex forming a broad indefinite V is fairly constant but the red on the clypeus and front is entirely absent on some specimens. It is probably secondary. The dark green coloration of the body is nearly gone in some specimens but the narrow lighter ivory or light yellow dorsal band is constant. Some specimens have more brown in the wings than occurs in the type.

A tree species collected July to March at Hatte Lathan and Damien by beating trees and bushes. Several specimens

were reared. Egg deposited February 1; hatched February 5; spun February 15; adult February 26. Larva is of the trash carrier type. One larva taken on bamboo and reared to adult. The adult was a little under size, length 13 mm.

Chrysopa dozieri n. sp.

A small green, non-trash carrying species readily recognized by the two comma shaped red spots on the vertex, sometimes forming a loop, by the red suffusion on the clypeus and the dark sectoral veins. Banks says this species is close to *torrei* Navas but the latter species has red on sides of thorax and the palpi are very black.

Head light yellowish green. A bright red suffusion under each eye and extending along the fronto-clypeal suture, not in the form of a definite red genal band as occurs in *C. plorabunda*, for example. Palpi with narrow black or brown longitudinal band on outside of segments. Vertex yellow with a pair of bright red marks resembling parentheses faintly connected below. Rest of head yellowish green. Antennae wholly yellowish, last segment black, reaches to the tips of folded wings. Body with a dorsal ivory median band bordered by yellowish-green areas. Lateral border of pronotum darker green, brightly marked with blackish brown. Rest of body yellowish green, ivory band extends entire length, especially prominent over the thorax. Fore wings with gradates blackish, also sectoral, medial and cubital cross veins blackish at the ends in basal half of front wings. Wings are narrow and somewhat angular at the tip. $M_3 + 4$ fuses at the cross vein. Gradates 6 (outer) and 5, entirely brown. Stigmas unmarked. Hind wings with 7 gradates (outer), 4 in inner. Basal 3 marked with blackish. Legs wholly yellowish green.

Total length is 13 mm. Length of front wing, 10 mm.; width, 3 mm.

Specimens collected primarily on cotton but also by beating trees and bushes in December to February. Localities at Damien, Hatte Lathan and Gonaives, Haiti.

Specimens differ as to the amount of red on the clypeus, on the vertex and as to size. In some, the red dots on the vertex are very faint and rarely they are rather diffuse. Paratypes measure up to 14 mm. long. Dorsal ivory band is less distinct on some specimens.

About a dozen were reared from larvæ to adult. The larvæ resemble those of *Chrysopa rufilabris* of the U. S. except that the reddish markings are lighter and less extensive, especially in the metathoracic region. The two longitudinal

head bands are the same. Body with 2 irregular dorso-lateral maroon bands from head to tail. Border, including tubercles, is yellowish. The cocoons are spun on leaves.

Named in honor of Dr. H. L. Dozier who was Entomologist on the staff of the Service Technique, in Haiti, from 1929 to 1931.

Type in Museum of Comparative Zoology.

***Chrysopa estradai* Navas.**

NAVAS: Rev. R. Acad. 1924, 21, p. 334.

Resembles *dozieri* and *exterior* of Haiti and *C. rufilabris* of the U. S. but there are more dark cross veins than in the latter and there is a definite median ivory band. This species may be recognized by the absence of red on the vertex and the definite red bands from eyes to mouth. -

Face light yellow with broad light red band from eyes to the mouth; no other markings. Both palpi with black longitudinal line on outside of segments. Vertex of head with slight indefinite reddish marks. Antennae wholly yellowish, unmarked except distal segments light brownish; reach to tips of folded wings.

A yellowish median ivory band extending the length of the body; somewhat indefinite at the start but prominent over the mesothorax and anterior part of the abdomen; borders of pronotum are darker green with faint maroon markings at anterior angles. Rest of body yellowish green.

Front wings narrow, with gradates entirely black. Outer series of 5 about twice their length from the margin of the wing. Inner series of 4 veinlets about midway in the sectoral area. Costal, sectoral, radial and medial cross veins in the basal half of the wings black at the ends. Median loop fuses before the cross vein. Hind wings with gradates 3, (inner) and 5 (outer), blackish. Stigmas greenish, indistinct. Legs entirely yellowish green.

Total length, 10 mm. Length of front wing is 9 mm., width is 3.5 mm.

Other specimens show absence of reddish blotching on vertex. Gradates outer, 5 to 7; inner 5 to 6. Four specimens collected December to February, by beating trees and cotton which is grown on tree-like bushes in Haiti. Three specimens collected on cotton December and February inclusive.

***Chrysopa antillana* Navas.**

Banks says that no formal description of this species was published by Navas but that it was included in a synoptic table in 1924. The name is therefore valid.

This species is readily recognized by the unusually long neck with a pair of bright red dorso-lateral bands and the inner series of gradates is located exceptionally basad.

Head yellow throughout. Face elongate, somewhat triangular. A broad, bright red band from eyes to mouth over the genae. No suffusion of red on clypeus. Palpi yellowish with black line on outside of the segments. Antennae yellow (broken off), vertex yellow, unmarked.

Pronotum very long and slender, fully twice as long as broad; yellow without median band, but with a pair of bright red dorso-lateral lines extending from the anterior angles to the last transverse, pronotal suture, stopping short of the mesonotum; the red bands are more than their width from the lateral margins. The remainder of body light yellow with darker yellow band each side of abdomen. Venter yellowish gray. Legs uniformly yellowish.

Front wings with an outer series of 7 (6 in other wing) gradates and an inner series of 3, wholly reddish brown. Inner series far basad, about twice their length from the radial sector. Cross veins in the basal half of wings black at ends or in entirety. The median loop ends beyond the cross vein. Hind wings with an outer series of 5 and an inner series of 2.

Total length, 16 mm. Length of front wing, 13 mm. Width, 5 mm. A single female specimen, without date.

Chrysopa wolcottii n. sp.

A very pallid, small, species characterized by the absence of any decided body markings, the inner series of gradates usually only 2 or 3 brown veins, the lower one not parallel to the others. Resembles *thoracica* but may be distinguished as indicated in the key.

Entire head and antennae yellowish, without any color spots or marks except as a result of fading. Distal segments of palpi entirely black.

No dorsal yellow median band on body. Pronotum yellowish green, without lateral markings. Abdomen darker yellow, or yellowish brown.

Wings very dark; gradates of front wings 5 and 2, wholly black; basal vein of inner series not parallel to the others. Most all other cross veins very dark or black. Median loop fuses just beyond the cross vein. Stigmas obscure. Hind wings with two rows of gradates, 5 and 2. Basal vein of inner series again not parallel to the others.

Total length, 12 mm. Length of front wing, 10 mm., width, 4 mm

Type, a male, collected at Damien by the writer and deposited in the Museum of Comparative Zoology.

Named in honor of Dr. Geo. N. Wolcott who began the Entomological work of the Service Technique and continued in charge for four years.

Seven specimens collected at Damien. Collection dates were November to February. This species was not reared and the host plants are not known.

While all the specimens have faded, the wings of all are quite dark. Basal gradate of inner series not parallel to others. Gradates in front wings vary 2 to 4 (inner) to 5-7. The inner series usually is of only two brown veins however. The entire head of four specimens is brownish in color. This is believed to be only secondary coloration since the wings are all very close to those of the type. The total length varies from 11 to 15 mm.

***Chrysopa freemani* n. sp.**

Resembles *C. villosula* Navas and *Chrysopa cubana* Hagen but lacks the prothoracic red stripes of latter. This is a small distinct species of *Chrysopa*, with prominent orange triangular areas behind the antennæ, a red band on the upper side of the basal segment of each antenna, two brown spots on the mesothoracic tergal lobes and very dark wing venation.

Head ochreous in color, no clypeal or genal marks. Maxillary palpi practically entirely black in color, while the labial palpi are amber. Antennæ without marks. A triangular area enveloping the antennal sockets extending somewhat below the antennæ and to the pronotum above, is pronounced light yellow in color. Antennæ unmarked except basal segment has a dark red band on upper side.

Lateral margins of pronotum is suffused with red. Median portion light green. A prominent purplish quadrilateral spot on the front of each mesoscutal lobe. Rest of body yellowish green. No dorsal ivory band. Legs wholly yellowish.

Wing veins largely dark. Gradates, inner series of front wings of 4 and outer series of 6, wholly black. Median loop fuses beyond the cross vein. Stigmas fairly prominent, yellowish green in color. Hind wings fairly dark, with gradates 5 (or 6) and 2; wholly dark reddish brown. Costal, sectoral and other cross veinlets in basal half of wing deep reddish black. Length of front wing, 11 mm.; width, 3.5 mm. Total length, 12.5 mm.

The type, a female, was taken November 16, 1929 at a porch light at an altitude of 500 ft. in Port au Prince. There were some sour orange trees in the yard heavily infested with the black aleurodid. The species probably has a trash carrying

larva as this type of larva greatly predominated among these aleyrodids. A single paratype, without date, differs only in that the mesoscutal purplish spots are less definite. The whole lobe is streaked with brownish-purple.

The species is named after Dr. George F. Freeman who built the Service Technique and formulated an educational policy for Haiti.

Type in Museum of Comparative Zoology.

***Chrysopa lioni* Navas.**

NAVAS: Bol. Soc. Iber. Cien. Nat. 1927, p. 54.

This species has been described from Port au Prince, Haiti. The following is the writer's translation of the original latin description.

"Chrysopa lioni sp. nov.

Yellowish brown. Head with eyes dark coppery. Apex of antennae somewhat dark; palpi yellowish-brown, last segment of labial palpus dark, elongate.

Prothorax transverse, margins parallel, anterior angles obliquely truncate, meso- and metanotum yellowish-red on the sides.

Abdomen yellowish, pilose; venter yellowish.

Legs brownish, with brownish pile, posterior tibiae slender, scarcely compressed.

Wings hyaline, iridescent, venation yellow. Stigmatic pile and border similar in color, with few gradate veinlets. Apex of anterior wings subacute, many veins brown; divisionary cell narrow, elongate, 5 intermediate veinlets, first united basad and near the apex of the divisionary cell, gradates 3-5.

Apex of the posterior wings acute. No veins dark except costals. Gradates 2-5 or 3-5.

Length of body, 6.8 mm. Length of anterior wings, 10.1 mm. Length of posterior wings, 9 mm."

Country, "Haiti, Port au Prince, G. Lion, 1910" Paris Museum."

No specimens conforming to the description of Navas have been seen by the writer.

***Leucochrysa haitiensis* n. sp.**

A fine large species similar to *L. floridana* but with two longitudinal red lines on the upper side of the basal segment of the antennæ, with four pairs of dark spots on the pro- and

mesonotum and with conspicuous brownish stigmas in both pairs of wings.

Face ivory, no markings on palpi nor genae. A small brown spot between and somewhat below the antennae; with a pair of chocolate red longitudinal lines forming a V-pattern on the vertex above the basal segment of each antennae and extending to the compound eye. Antennae with two longitudinal dark red bands on the upper side of each basal segment, and a part of the 2nd segment also.

A chocolate-brownish, narrow band at each side of the pronotum only partly visible on the dorsum. A pair of dark brown dots dorsally near the posterior margin. A pair of chocolate-brown spots on the mesoscutum, another pair on the mesoscutellum and another on the base of each wing at the origin of the anterior veins of the wings. Rest of body and legs without distinguishing marks. •

Genitalia, a specialized expanded structure, with a small brown spot on each upper lobe. Both lobes covered with prominent yellowish hair. The small circular areas laterally are unusually large, situated on a hyaline area and sparsely beset with relatively long setae.

Wings with most of cross veins in the posterior half of the wing partly or wholly black (Pl. II, Fig. 20). The anal and cubital branches are particularly dark. Median loop entirely black. Cell within is clearly angulate, fusion of median branch is well beyond the cross vein. Two series of gradates of either 6 or 7 each, about equally spaced; veins nearly or wholly black. Hind wings with two series of gradates, only partly brown, a portion of Rs beginning about two-thirds of distance from origin to beneath the stigma is conspicuously black. Stigmas prominently brownish in both pairs of wings. Sc brown in stigmal area.

A fine, large species 17 mm. from head to tip of wings. Length of front wing, 15 mm.; width, 5.5 mm.

Type, a male, collected Feb. 15, 1929, on papaya by the writer and deposited in the Museum of Comparative Zoology.

Adults collected on feterita, papaya, on artichoke, taken at lights, and reared December to March inclusive. Eggs are white in color, appearing like hatched eggs of common North American species. Larva a trash-carrier with a very dark color pattern (see Pl. II Fig. 5). Head dark brown except for narrow yellowish areas between the spots. Dorsum very brown. Lateral tubercles whitish or yellowish forming a light band each side of the body. Venter very brown. Cocoon entirely covered with trash. Life history: egg stage, 4 or 5 days; larval, 14 to 25 days; pupal, 15 to 25 days.

MYRMELEONTIDÆ.

Haiti has a fairly good population of Myrmeleontids. The larval pits were very plentiful in the late fall and early summer under the eaves of buildings, in the earthen floor garages and in the sand along creeks. A large collection of larvæ was made the latter part of April near the Bassin Générale and at Hatte Lathan June 8, 1929. Some of the adults were reared from larvæ collected in pits in the Cul de Sac region while others were collected at lights. It was interesting to observe the difficulty the larvæ had keeping the pits open on windy days.

Glenurus cerverei Navas.

This fine large species, of which six specimens were collected in Haiti superficially resembles *Dendroleon obsoletum* of the U. S. except as to wing spotting (Fig. 13), and body coloration. It was identified by Banks.

A black band across the face at the antennae, a brown carina extending across the vertex, dark brownish occiput with longitudinal brown bars near median line and a large black spot near each eye. Remainder of head light brownish in color. Palpi yellow; distal segment of labial palpus swollen in middle and blackish at the tip. Antennae with slender cylindrical segments. Each segment is black basally and reddish brown distally. Two basal segments completely black; club of flattened segments, black in color.

Prothorax uniformly grayish or purplish-brown dorso laterally; a light median line and with black areas each side, the black broadens, converging slightly posteriorly. Rest of thorax brownish with mottled areas of darker brown. Abdomen dark brown, each segment whitish along the anterior border. Venter of body very light brownish in color. Legs relatively long and slender, with alternate white and black bars. Sparsely beset with slender white and black bristles. Tibial spurs approximately as long as the first three tarsi, brown and slightly curved.

Wing venation and spotting as indicated in Figure 13. Length of front wings, 32 mm.; width of front wing, 7.5 mm. Total length, 37 mm.

Six specimens from Damien and Port au Prince January to December. One specimen, collected August 1924 by Dr. G. N. Wolcott at Port au Prince, is very much undersize. Length of front wing 22 mm. Total length 28 mm. This specimen may be a variety of *haitiensis*. The wing markings are distributed similar to Figure 13 but the marks are smaller and light brown in color. The head and thoracic markings are the same as described. There is some variation in the spotting chiefly as to the size of the spots. The triangular area in the

middle of the posterior margin of the front wing is entirely fuscous in some wings and clear in others.

***Vella fallax* subsp. *haitiensis* new subspecies.**

RAMBUR, 1842. Hist. Nat. Ins. Neur., p. 385. (*Myrmeleon*).

This fine large form differs from *V. fallax* according to Banks in only a few characters. He says this is not identical with *V. eggerti* Petersen from St. Thomas which has one series of cells between all the branches of the radial sector as this species from Haiti has two series between several branches.

(ESSEN-PETERSEN. Deutsch. Ent. Zeitschr., 1928, p. 74-75. *V. eggerti* n. sp.)

Face is yellow, antenna missing on the type. Labial palpi usually long, yellow. Pronotum about as broad as long; a black narrow Y-shaped, median band with anterior arms of the Y fusing at the head; black converging bands at the side and yellowish-brown dorso-laterally. Rest of thorax predominately brownish-black with some yellowish spots between. Venter of thorax yellowish-brown, rather thickly beset with long hair mostly white in color. Legs yellowish beneath, but largely blackish or brownish above; thickly beset with long white hair. Tibial spurs strongly curved and as long as first three tarsal segments. Tarsi black. Banks states that this specimen differs from typical *fallax* by having only one spine behind on the middle femora instead of two.

Abdomen brownish-black but somewhat indistinctly striped with dark yellow longitudinal dorsal lateral bands.

Venation shown in Figure 16 which, however, does not show the light and dark areas on the veins. Wings have the appearance of being lightly brown and gray barred. Membrane without spots, veins irregularly alternately light and dark spotted. Stigmas yellowish-white. No Banksian line in the hind wings.

A single female specimen collected by Dr. George N. Wolcott May 1927 at Jacmel, Haiti. Length of fore wing 58 mm. width 9 mm. Total length 66 mm.

***Psammoleon bistictus* (Hagen).**

Syn. Neur. N. Amer., Smiths, Msc. Colls., 1861, p. 235. (*Myrmeleon*).

Lower part of face and palpi light yellowish or amber. A black bar slightly beset with short white hair across the face in region of antennæ.

Vertex with two black transverse undulate carinae, between which there is a black and grayish color pattern. Three basal segments of antennae yellowish, prominently marked with dark brown; remaining segments nearly wholly light brown. Club of antennae very light brown, alternately banded with light to dark brown.

Prothorax nearly wholly brown except for some darker brown patches with two pairs of lighter areas dorso-laterally and a gray median line. Rest of thorax and abdomen predominately dark brown with lighter brown areas between, forming an intricate pattern. Tip of abdomen with prominent black setae.

Legs slender; coxae and femora of last two legs wholly yellowish with long stout gray setae and a few black ones. The first two pairs of legs prominently marked with brown. Hind pair almost entirely yellowish in color, sparsely beset with black and gray spines. Tarsi banded with black. Tibial spurs light brown in color, slightly curved, equal in length to the first three tarsal segments of the front and the first two segments of the other legs. Tarsal claws simple, shorter than tibial spurs.

Wings as illustrated in Figure 14. Stigmas whitish. Prominent black barring along R. and two black bars along cross veins, one in radio-medial area and a short one basally in cubital region.

Four specimens collected by the writer November to January, one of which was taken from a spider web on a ceiling of a porch. This and many other insects had been apparently attracted there by the light and became entangled in the web.

Length of front wing 27 mm., width is 6.5 mm. Total length head to tip of closed wing 31 mm. Expanse is 54 mm.

Austroleon indiges Walker.

A small, delicate, slender bodied, slender winged species, without prominent wing or body markings and resembling, superficially, some of the smaller damsel flies. Banks, who determined these specimens, stated that *Clathroneuria cubitalis* Navas of Cuba is a synonym.

Face yellowish, shining, brownish-black bar between and below the antennae, a circular, somewhat crescent-shaped grayish-black bar above the antennae, a narrow slightly crescent, yellow bar between the two spots joining the antennae. Vertex with a complex four-pointed blackish-brown bar extending from eye to eye with yellowish areas around the brown spot. Occiput with two dorso-lateral longitudinal, brown bands which extend posteriorly over the praescutum.

Antennae dark brownish, due to short brown setae, but each segment with a narrow yellowish ring, caused by absence of brown setae at both ends of each segment. Basal segment yellowish with brown clouding laterally. Club flattened, lighter and more yellow beneath; basal half nearly wholly brownish black.

Pronotum, except the praescutum, with five brown longitudinal bands, two lateral, two dorso-lateral and one median. These bands extend over the rest of the thorax, but are irregular, giving this region the appearance of having four broad, brown stripes with the intervening areas light yellowish.

Abdomen very long and slender, 28 mm. in length; brownish below, basal half largely yellowish above, distal half brown. Segments 1 and 2 very short, approximately equal in length; segment 3 the longest, 6 mm. long, yellowish with two brownish longitudinal spots dorsally, one anteriorly and one posteriorly; 4th segment similar except the brown on the sides extends dorso-laterally between the two dorsal spots and is visible dorsally, slightly broadened just below the middle and nearly wholly brownish black; 5th segment broadened anteriorly, very dark; segments 6 to 8 inclusive, are very dark brown. Anal appendages 2, gray, flattened, downward-curving projections, set with brown setae. Abdomen thickly beset with short brown setae, not obscuring the surface, however. About 9 pairs only of short black setae on the pro- and mesothorax.

Wings as illustrated in Figure 18. Length of front wing, 18 mm. Greatest width, 4 mm. Hind wing, 17 mm. Width, 3.5 mm.

Total length, head to end of abdomen, 31 mm.

A male, collected Cul de Sac plain May 12, 1927 by Dr. Geo. N. Wolcott and two males collected January 5, 1929 by the writer.

***Myrmeleon insertus* Hagen.**

Synopsis Neur. N. Amer., Smiths, Misc. Colls. p. 233-234, 1861.

The most common species of myrmeleontid on the Cul de Sac plain region in Haiti. A fairly large species with somber markings, (See Plate II, Fig. 15). These diagnostic notes are given to supplement Hagen's description.

Head black from near fronto-clypeal suture to middle of vertex; portion immediately below antennae shining black, dull grayish black above. Two black spots on the clypeus. Palpi banded with light brown. Antennae entirely black except for a narrow yellow region on the basal segment and narrow intersegmental yellowish bands; black region rugose, sparsely beset with short coarse black setae. Club of same coloration. Upper surface of club deeply sunken, producing a dipper effect. Vertex with two dull black sub-median bands extending to pronotum, interrupted with yellow at their middle. Two pairs of longitudinal lateral dull black bars extending mesad from the compound eyes.

Three black longitudinal bands on the pronotum, a median one broadened near the middle and a pair of black lateral bands with two projections medianly. Remainder of thorax and entire abdomen almost wholly dull brownish black, sparsely beset with short decumbent glistening white hair. Last two segments of abdomen with a yellow spot distally on dorsum. Genitalia thickly beset with shining black, short, stout setae.

Wings as shown in Figure 15. Main longitudinal veins alternate brown and gray. Sc, R and Cu are prominently brown and gray spotted. Stigmas whitish.

Legs slender, yellowish. Femora with light brown band distally. Tibiae with brown longitudinal band dorsally. Each tibia with a pair of slightly curved tibial spurs, shorter than the first tarsal segment. First tarsus approximately equal in length to next two, tending to be a little shorter. Last tarsal segment as long as first three together, black distally. Claws simple, slightly curved; legs with few long black setae only.

Total length, wings folded, 32 mm. Length front wing, 28 mm. Width, 5.75 mm. Length hind wing, 27 mm. Width, 4.75 mm.

Fifteen specimens, about half of them reared. Some adults also taken at lights. Collected October to May. Larvæ collected at Sisal plantation, Hatte Lathan, December 15. Spun January 4. Emerged February 7.

ASCALAPHIDÆ.

Five species of *Ascalaphids* from Haiti have been seen. Most of them were collected on a radio aerial on our home. The adults rested, usually, with the body close to the wire and with the wings and antennæ hanging downward in the characteristic position often described. One adult was taken on a rose bush and one larva was collected.

Ululodes macleayana venezolensis Van der Weele.

Monographisch Bearbeitet, Coll. Zoologiques, 1908, p. 103-104.

Five specimens, August to December, most common in August to November inclusive however. These specimens conform to the illustration and description of Van der Weele, pp. 103-104, very closely. The wings are shown in Figure 19. The hair on the head and body is predominately light brownish. The female lacks the blackish clouding in the hind wings below the stigma.

Two females deposited eggs, (Fig. 6) and some of the eggs hatched. The larvæ (Fig. 9) would not feed and became lost when put into sand.

Ululodes subvertens (Walker).

Brit. Mus. Cat. Neur., p. 437, 1853.

Two specimens taken from the Cul de Sac plain of Haiti near Port au Prince which conform rather closely to Van der Weele's description and illustration pp. 113-114. Hair on the head is largely white. One specimen collected by the writer

August 1929, one female collected by Dr. Wolcott, November 20, 1927. The wings of a specimen from Haiti are shown in Figure 17.

***Ululodes sancti-domingi* Van der Weele.**

Monographisch Bearbeitet, Coll. Zoologiques, 1908, p. 115.

Three specimens, which conform to Van der Weele's account p. 115, collected by the writer. One collected in September, one in April, and the third specimen, which is in poor condition, is without data.

The hair on head and thorax is predominately black. The body color is black or brownish-black. The wing veins and stigmas are shining, dark, reddish-brown.

***Ululodes banksi* Van der Weele.**

Monographisch Bearbeitet, Coll. Zoologiques, 1908, p. 115-116.

One specimen collected by Dr. Wolcott, May, 1925. Described by Van der Weele pp. 115-116. Wings are shown in Figure 21. The venation is very similar to *venezolensis*, Figure 19. The antennæ are predominately yellow. The hair covering of head and thorax is gray and black mixed, nearly equal in amount. The wing veins are shining brown but the stigmas are very light brown. The veins are lighter brown in the distal half of the wing.

One specimen without date. The brown coloring of the membrane of the wing makes this species easy to recognize. The hair on the head is grayish, black at tips. Specimen is smaller than Van der Weele's measurements. Front wings 25 mm. x 7 mm.

CONIOPTERYGIDAE.

A single specimen only of this family was taken in Haiti. No special effort was made to collect *Coniopterygids* so this paucity does not indicate that they are rare. Dr. J. C. Myers stated to the writer that he saw them in numbers on evergreens in the region of Kenscoff.

***Coniopteryx haitiensis* n. sp.**

Tribe Coniopterygini Enderlein.

This specimen keys out to *Malacomysa* in Bank's key, (p. 80, 1906) and to *Coniopteryx* in Enderlein's key (p. 6, 1908).

Coniopteryx appears to be the valid name for the genus. Cu 1 of the front wing is not sharply bent. The basal segments of the antennæ (Fig. 7b) are not elongated or are equal to only about two other segments and no sense organs were seen on the segments. A drawing of the wings is shown in Figure 7a. The prominent axillary lobe of the hind wing is diagnostic.

Head amber colored except a broad black bar on the front between the antennae extending from the clypeus to the middle of the vertex. Antennae filiform with 25 segments.

Body pinkish in color, bare, abdomen short, gray in color. Wings grayish white, membrane clothed with a fine scaly covering.

Legs without bristles, amber colored.

Length of front wing, 1.98 mm.; width, 9.46 mm.; length of hind wing, 1.76 mm.; width, 6.45 mm. Length of antennae, 1.03 mm. Total length, head to tip of folded wings, 2.58 mm.

Type mounted on a slide. A single female specimen, collected December 20, 1929 by beating the branches of a tree (*Inga vera*) near Damien, Haiti. Deposited in Museum of Comparative Zoology.

BIBLIOGRAPHY.

- Banks, Nathan.** A Revision of the Nearctic Hemerobiidae. Trans. Amer. Ent. Soc., 1906, 22: 21-51, 5 pl.
 A Revision of the Nearctic Coniopterygidae. Proc. Ent. Soc. Wash., 1906, 8: 77-86, 2 pl.
 A Revision of the Nearctic Myrmeleonidae. Bul. Mus. of Comp. Zool., 1927, 68, No. 1, 84 pp., 5 pl.
 A Revision of the Nearctic Chrysopidae. Trans. Amer. Ent. Soc., 1903, 29: 137-162.
- Enderlein, Gunther.** Neuroptera, Family Coniopterygidae. Gen. Insectorum Fasc. 1908, 67, 18 pp., 3 pl.
- Hagen, Hermann.** Synopsis of the Neuroptera of N. A. Smithsonian Misc. Pub., July, 1861, 347 pp.
- Navas, L.** Algunos Insectos de Cuba. Rev. Real Acad. Cien. Madrid. T. 21, 6, 2nd Ser., 1923 (1924), pp. 325-338.
- Smith, Roger C. and Andre Audant.** The More Injurious Insects of Haiti. Jour. Econ. Ent., 1930, 23: 972-979.
- Van der Weele, H. W.** Monograph of the Ascalaphidae (Trans Title). Collections Zoologiques du Baron Edm. de Selys Longchamps, Fasc. 8, 1906, pp. 326, 2 pl.
- Wolcott, George N.** Insectae Portoricensis. Jour. Dept. of Agr. Porto Rico, 1923, 7, No. 1. (Neuroptera, pp. 31-35.)
 Entomologie d' Haiti. Service Technique, Dept. of Agr., Port au Prince, Haiti, 1927. (Neuroptera, pp. 163-165.)

EXPLANATION OF PLATES.⁴

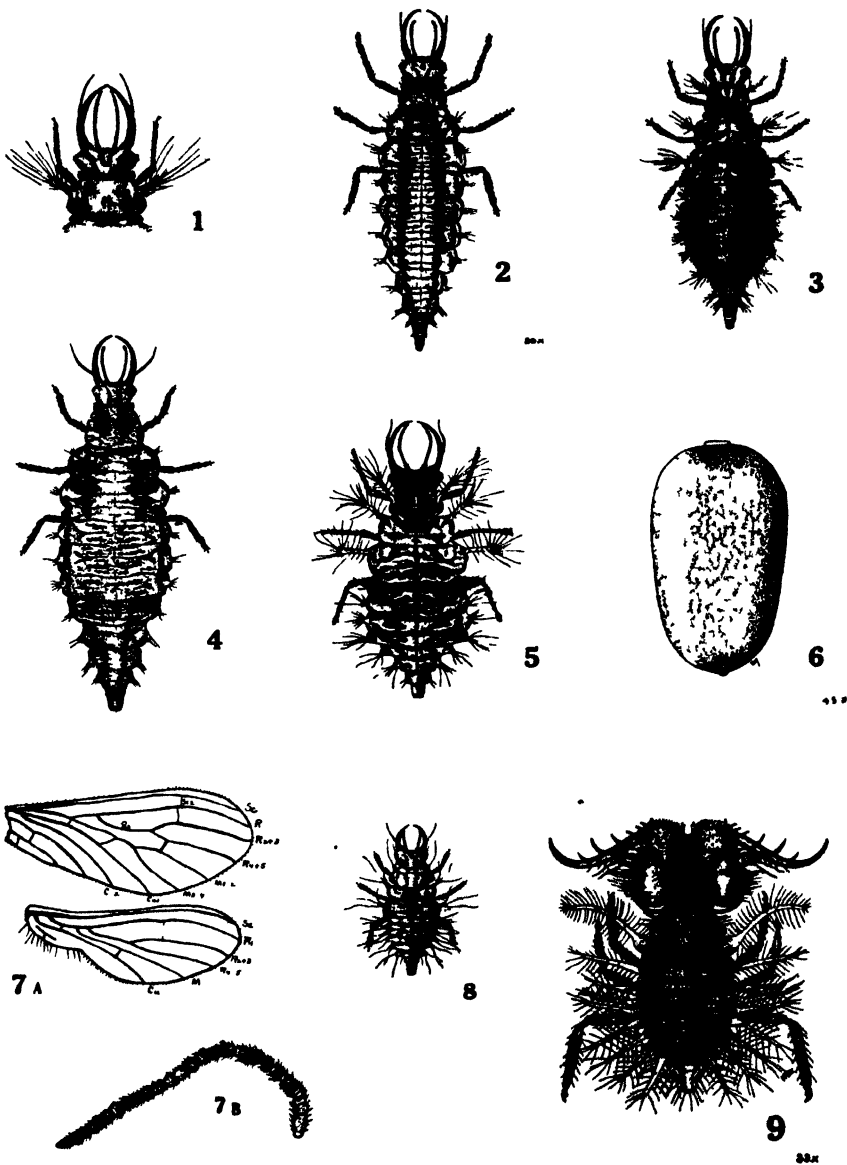
PLATE I.

- Fig. 1. Head and prothorax of third instar larva of *Chrysopa damiensis* Smith. This was the most common trash carrier seen. The middle marks on the head were not always clearly fused into a loop.
- Fig. 2. Third instar larva of *Chrysopa exterior* Navas. This is a non-trash carrier of the *C. plorabunda* type, but the middle, black, triangular bar on the head is specific. $\times 7$.
- Fig. 3. Third instar larva of *C. thoracica* Walker, which is a dark trash-carrying type.
- Fig. 4. Third instar larva of *C. dozeri* Smith. The larva is of the type of *C. rufilabris*, but this species has more red in the dorso-median area particularly of the thorax, ordinarily somewhat more than is shown in the drawing. $\times 7$.
- Fig. 5. Fully grown larva of *Leucochrysa haitiensis* Smith, showing an unusual head pattern and a very dark body coloration for a trash-carrying larva. The dorsal hooked setae, common to trash carriers, are not shown in the drawing.
- Fig. 6. Egg of *Ululodes macleayana venezolensis* Van der Weele.
- Fig. 7a. Wings of *Coniopteryx haitiensis* Smith.
- Fig. 7b. Antenna of *Coniopteryx haitiensis* Smith. Venation after Withycombe: Entomologist, 1922, 4: 224-225.
- Fig. 8. First instar larva of *Leucochrysa haitiensis* Smith. Note that there are only two spines from each lateral tubercle except the second and third thoracic ones which have three each as in *Chrysopa* larvae.
- Fig. 9. Newly hatched larva of *U. venezolensis*.

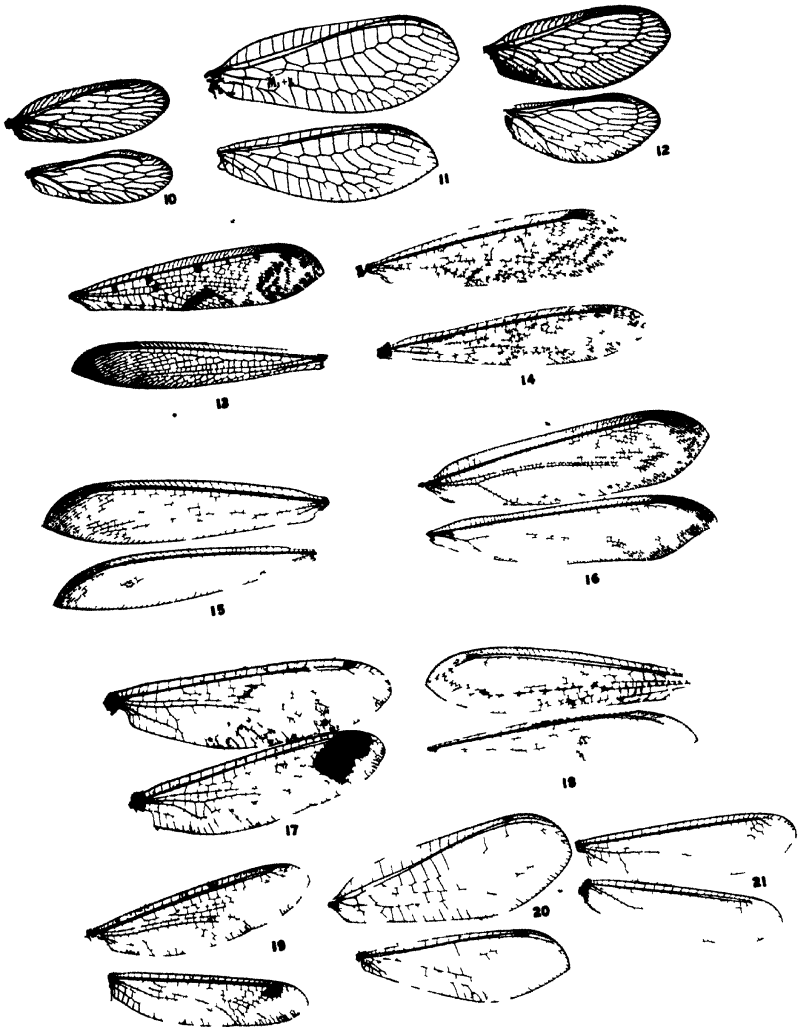
PLATE II.

- Fig. 10. Left wings of the type of *Micromus haitiensis* Smith.
- Fig. 11. Right wings of a paratype of *Chrysopa damiensis* Smith.
- Fig. 12. Right wings of type of *Nusalala damiensis* Smith. Note the dark brown line along the outer gradates.
- Fig. 13. Wings of *Glenurus cerverai* Navas.
- Fig. 14. Right wings of *Psammoleon bistictus* Hagen. The powdery effect is due to foreign materials on the wings.
- Fig. 15. Right wings of *Myrmeleon insertus* Hagen.
- Fig. 16. Right wings from the type of *Vella fallax* sub sp. *haitiensis* Smith. The brown and gray areas on the veins are not shown in the photograph.
- Fig. 17. Right wings of *Ululodes subvertens* (Walk.).
- Fig. 18. Wings of *Austroleon indiges* Walker.
- Fig. 19. Right wings of *Ululodes macleayana venezolensis* Van der Weele. The black spots basad and distad of the stigma in the front wings are not wing markings, but foreign material on the wing surface.
- Fig. 20. Right wings of *Leucochrysa haitiensis* Smith.
- Fig. 21. Right wings of *Ululodes banksi* Van der Weele.

⁴Drawing 6 by Fritz Maximilien, 7a and 7b by the writer and all of the others by Pierre Noel.



Neuroptera of Haiti
R C Smith



KINESTHETIC SENSE OF INSECTS.*

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In spite of the large number of valuable observations which have been published concerning the behavior of insects, it is rather striking that the kinesthetic sense remains a neglected factor. In recent years a new theory of geotropism has been developed by Crozier and his school. This theory is in sharp contrast to the now obsolete statolith hypothesis of orientation to gravity. It is now beyond question that in a large number of diverse organisms, including mammals and insects (Crozier, 1929), the direction of the organism in a gravitational field is determined by the body weight acting upon the "tension receptors" in the supporting musculature of the limbs. The writer (Barnes, 1929, 1930a) has shown that the angle described by an ant crawling upon an inclined surface is a precise function of the sine of the angle of inclination of substratum. The insect turns until the "pull" of the body weight on both sides of the supporting musculature is reduced below threshold value. The same phenomenon has been observed in *Malacosoma* larvae, in *Tetraopes*, and several other insects. Unfortunately we have no knowledge of tension receptors in insects, either from the physiological or histological point of view. In rats, however, the muscle tension theory of geotropism is supported by a great deal of valuable evidence concerning the histology of the vertebrate muscle spindle and the nervous discharges produced by these sense organs when stimulated by tension. The present investigation was undertaken with the hope of discovering muscle tension receptors in Arthropods. The writer (Barnes, 1930b) has recently published an account of the physiology of the tension receptors in Crustacea and the present note deals with afferent impulses from insect muscle.

The work was carried on at the Biological Station in Bermuda during the summer of 1931. The apparatus employed con-

*Contributions from the Bermuda Biological Station for Research.

sisted of an amplifier, constructed of radio parts after a design by Professor A. Petrunkevitch, to whom the writer is greatly indebted for much helpful advice. Three Ux 240 wireless valves, having a high amplification factor ($\mu=30$) were connected to a power valve 171A ($\mu=3$), all of which were resistance coupled. In the absence of an oscillograph the amplifier was wired to a loud speaker. A resistance of two megohms was employed between the nerve and the ground wire. The nerve was placed across cotton points, soaked in physiological solution, leading from Ag-AgCl electrodes (unpolarizable). It was found that insect nerves survive an hour or more in seawater diluted two-thirds with distilled water. The metathoracic legs of large specimens of *Periplaneta* were cut off at the coxa and the entire nerve in the femur was carefully dissected out in the solution. As far as possible no metal instruments were allowed to come in contact with these unmedullated fibers; fine glass hooks were found to be very suitable for manipulating the nerve trunk. The femur was held firmly by a muscle clamp and the nerve was placed gently across the cotton electrodes. A natural form of stimulus was used throughout, i. e., bending the various segments of the leg.

It was very gratifying to find that the slightest movement of the limb produced a discharge of sensory impulses which were led off through the electrodes and reproduced faithfully by the loud speaker. The sound resembled very closely the discharges from the muscle spindles of the frog and the muscle receptors of the crab and lobster. It is obvious that the presence of these afferent action currents in the femoral nerve is a beautiful confirmation of Crozier's theory of geotropic orientation. The frequency of the discharge was proportional to the extent and rapidity of the leg movements.

It is not advisable at present to attempt to report other characteristics of these afferent impulses. Further work is necessary to determine the rapidity of the adaptation to the stimulus. Following the well-known terminology of Adrian (1928) rapid adaptation of the sense organ signifies that it does not give rise to a persistent discharge of impulses during a persistent stimulus. In other words, the polarized membranes concerned are discharged during the initial period of stimulation. The question of adaptation of tension receptors is not without significance for the problem of maintained posture. In a

previous communication (Barnes, 1930c) it has been pointed out that marine Crustaceans which are not capable of maintaining a standing posture have tension receptors which exhibit rapid adaptation in contrast to the muscle spindles of vertebrates, whose slow adaptation, or the ability to maintain a persistent discharge, enables the animal to hold a standing posture while the body weight is pulling on the supporting musculature. In the preparations studied, the adaptation of the tension receptors in the cockroach appeared to be rather rapid which seems incompatible with the habit of the insect of retaining a standing posture for long periods. We expect to return to this problem in the near future. The present report is to be regarded as further evidence supporting Crozier's theory of geotropic orientation which of course requires the presence of sense organs responding to tension.

Preliminary histological investigations were undertaken to locate the sense organs involved but vital staining with methylene blue failed to reveal structures in the muscle which might be regarded as sensory endings. In Crustacean muscle the author has been unable to find anything resembling the muscle spindles of vertebrates and in the crab and lobster it is not improbable that the movements of the limb give rise to afferent impulses which take their origin in the flexible integument at the joints which is folded or unfolded at every movement. The writer would be very glad to hear of any papers dealing with sensory organs in the muscles of insects.

BIBLIOGRAPHY.

- Adrian, E. D. 1928. The basis of sensation. London.
Barnes, T. Cunliffe. 1929. The positive geotropic orientation of an ant. Jour. Gen. Psych., Vol. 2, pp. 517-522.
1930a. The effect of gravity on the oscillations in the path of an ant. Jour. Gen. Psych., Vol. 3, pp. 318-324.
1930b. Sensory impulses in crustacean nerve. Jour. Physiol. LXIX, pp. 32.
1930c. Le diametre des fibres nerveuses des crabes en rapport avec leurs proprietes fonctionnelles. Comp. rend. CV, 385.
Crozier, W. J. 1929. The study of living organisms. Chapt. 2 in the "Foundations of Experimental Psychology." Worcester.

THE APHIDAE OF COLORADO.

PART I.

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The object in preparing this paper has been to give as complete a list as possible of the aphids infesting both the native and the introduced plants occurring in the State of Colorado, along with brief notes on food plants and life histories.

While we have endeavored to correctly determine all the species listed, we are well aware that there will be other students of the group who will not agree with us in all cases. We have not been so much concerned about this as we have about making clear the characteristics of the species being considered in each case. We have, therefore, taken considerable pains in presenting brief descriptions and carefully drawn figures to show important structural characteristics.

Keys are given to aid the beginner, especially, in the determination of species, and the list of host plants included in the index will enable anyone to determine quickly all the species of aphids that we have taken on any species of plant.

The plan of classification used by A. C. Baker in his paper on "Generic Classification of the Hemipterous Family Aphididae," (U. S. Dept. of Agri. Bul. 826, 1920) has been followed rather closely.

We are indebted to nearly every aphid specialist we know, in this country or Europe, for assistance in one way or another, in the preparation of this report on our aphid studies. Instead of attempting to list their names together here, we have endeavored to give credit in the write-up accompanying the species. However, we wish especially to acknowledge our great obligation to the late Mr. L. C. Bragg, who, as a great lover of nature and an enthusiastic worker, collected fully one-third of all of the material upon which this paper is based.

All of the illustrations are by the junior author.

Superfamily **Aphoidea.**

The *Phylloxeridae*, or *Adelgidae*, were formerly placed under the family *Aphidae*. Recently, however, two distinct families are recognized and these together comprise the superfamily *Aphoidea*. This paper deals with the *Aphidae** only.

KEY TO FAMILIES OF APHOIDEA.

- A. Females always oviparous. Antennae 3-5 jointed, shorter than head in apterae. Radial sector absent, stigmal vein formed by media; media simple..... **Phylloxeridae**
- AA. Summer females viviparous. Antennae usually 6-jointed, longer than head in apterae. Radial sector present; media branched in most species..... **Aphidae**

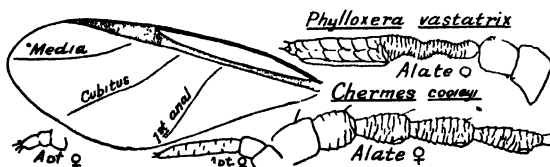


FIG. 2. Phylloxeridae.

Family **Aphidae.**

Characters.—Tarsi 2-jointed. Antennae usually 6-jointed, terminal segment with a slender prolongation or unguis. Cornicles usually present. Stigmal vein is the radial sector. Agamic forms never oviparous. Last segment of abdomen bearing a cauda.

KEY TO SUBFAMILIES OF APHIDAE.

- A. Exposed on plants. Antennae, cauda and cornicles well developed. Sensoria on antennae circular or oval. Wing veins not reduced. Wax glands not abundant.
 - B. Radial sector arising from stigma..... **Aphinae**
 - BB. Radial sector arising proximal of stigma..... **Mindarinae**
- AA. Concealed under secretions, or in folded leaves, in galls or on underground roots. Antennae, cauda and cornicles more or less reduced or wanting. Sensoria on antennae usually transverse or annular.
 - B. Aleyrodiform stages not found..... **Eriosomatinae**
 - BB. Aleyrodiform stages common..... **Hormaphinae**

*Not used in the restricted sense of Börner (Arch. Klass. Phylog. Ent. 1930) who separates the *Eriosomatinae* as a distinct family.

Subfamily **Aphinae**.

Characters.—Antennæ always longer than head and thorax, sometimes longer than body. Cornicles evident, either as cylindrical tubes or as raised rims. Cauda usually well developed. Compound eyes developed in apteræ. Sensoria on antennæ circular or oval. Oviparae usually laying several eggs. Living exposed on plants.

KEY TO TRIBES OF APHINAE.

- A. Cornicles on broad shallow cones. Radial sector usually straight.
- B. Cornicles and antennae hairy (except in *Essigella*). Radial sector straight (except in *Lachnus* and *ANOECINA*). Unguis thick, much shorter than base of VI. (Page 830)..... **Lachnini**
- BB. Cornicles and antennae not noticeably hairy. Radial sector curved. Unguis slender, nearly as long as base of VI. (Not recorded from Colorado.)..... **Setaphini**
- AA. Cornicles truncate or rather elongate or absent. Radial sector never straight.
- B. Cornicles bearing long hairs. (Not recorded from Colorado).. **Greenideini**
- BB. Cornicles never with long hairs.
- C. Thorax of alatae with dorsal lobes not prominently developed. Oviparae small, often laying but one egg; large wax plates present. (Not recorded from Colorado)..... **Thelaxini**
- CC. Thorax of alatae with lobes prominently developed. Oviparae laying several eggs. Large wax plates usually absent.
- D. Cornicles truncate or elongate, rarely rings or pores; when elongate the cauda is knobbed and anal plate bilobed, or antennae prominently hairy. (Page 882)..... **Callipterini**
- DD. Cornicles not truncate, usually elongate. Cauda never knobbed. Antennae with only a few spine-like hairs. (Part II)..... **Aphini**

Tribe **Lachnini**.

Characters.—Frontal tubercles lacking. Antennæ and body usually hairy. Secondary sensoria circular. Unguis much shorter than base of VI, if not, stigma greatly elongated. Cornicles mere rims, usually on broad hairy cones, or if not, stigma more or less elongate and radial sector straight. Cauda always broader than long, apparently semi-lunar and rounded but really ending in upturned point. Anal plate rounded, entire.

KEY TO SUBTRIBES OF LACHNINI.

- A. Hind tarsi never more than one-third length of tibiae.
- B. Hind first tarsal joint triangular, hardly longer than wide. (Page 831)..... **Anoecina**
- BB. Hind first tarsal joint distinctly trapezoidal, much longer than wide.
- C. Body narrow. Cornicles mere rings. (Page 835)..... **Eulachnina**
- CC. Body not narrow. Cornicles on hairy cones or, if not, rostrum lance-like.
- D. Radial sector straight, stigma not elongated to apex of wing. Tip of rostrum conspicuous, distinctly separated. (Page 841).... **Cinarina**
- DD. Radial sector more or less curved or stigma greatly elongated, attaining apex of wing. Tip of rostrum inconspicuous, not distinctly separated. (Page 875)..... **Lachnina**
- AA. Hind tarsi greatly elongated, second joint more than half as long as tibia; first tarsal joint minute. (Page 880)..... **Tramina**

Subtribe **Anoecina**.

Characters.—Antennæ 6-jointed, with long hairs and protruding subcircular or oval sensoria. Fore wings with stigma short and broad; radius curved, arising some distance proximally to tip of stigma; media once branched, not faint. Wings hyaline. Tarsi short and thick, Aphis-like; first joint of tarsi triangular. Cornicles on shallow hairy cones.

This group is placed under the *Pemphiginæ* by some but the characters of the cornicles, cauda, anal plate, hairs and sensoria seem to the writers to ally it to the *Lachnini*. The genus *Nippolachnus*, with its long stigma, seems to form a connecting link with that tribe, though it differs in the curved radius.

KEY TO GENERA OF ANOECINA.

- A. Head divided, ocular tubercles absent. Stigma long and straight, **Nippolachnus**
 AA. Head not divided. Ocular tubercles prominent. Stigma short and rounded..... **Anoecia**

[Genus **Nippolachnus** Matsumura.]

Type, *Nippolachnus pyri* Matsumura. (Matsumura, Jour. Coll. Agr. Tohoku Univ., Vol. 7, pt. 6, p. 382, 1917).

Characters.—Antennæ 6-jointed, with many hairs; sensoria prominent and protruding. Head divided. Ocular tubercles not prominent. Stigma long and narrow. Mediæ once branched. Cornicles on large broad cones entirely covered with hair. Spring forms free, migrating in summer to alternate hosts. Sexes small, males winged. Unknown in Colorado.

Genus **Anoecia** Koch.

Type, *Aphis corni* Fabricius. (Koch, Die Pflanzenlause Aphiden, 1857, p. 275).

Characters.—Vertex rounded; head not divided. Frontal tubercles absent. Antennæ inserted laterally or slightly ventrad; 6-jointed; covered with hairs; unguis much shorter than base of joint VI; sensoria subcircular or elongate. Fore wings with mediæ once branched; stigmæ short and thick. Hind wings with two cross veins. Cornicles on broad hairy cones. Cauda rounded, broader than long. Anal plate entire. Sexes apterous, with beaks and feeding. Oviparous female laying one to four eggs. Spring forms free, summer forms usually on roots.

Genotype, *Anoecia corni* (Fabricius). (See below).

KEY TO SPECIES OF ANOECIA.

- A. Sensoria narrow elongate, number, 6-19 on joint III of alate viviparae.
 Summer apterae with antennal joint III .30 mm. long. (Page 832)....**corni**
- AA. Sensoria oval, numbering 0 to 8 on antennal joint III of alate viviparae.
 Summer apterae with antennal joint III less than .30 mm. long.
- B. Sensoria in alatae nearly always large and uniform. Antennal joint III in Summer apterae shorter than .15 mm. (Page 833).....**quernei**
- BB. Sensoria in alatae rarely large. Antennal joint III in summer apterae longer than .15 mm.
- C. Unguis slender and finger-like. Apterae black. (Page 833).....**graminis**
- CC. Unguis stout, rather conical. Apterae yellow, usually with dusky markings.
- D. Antennal joint III of apterae .18 mm. long. On *Oenothera* roots.
 (Not taken in Colorado.).....**oenotherae**
- DD. Antennal joint III of apterae .24 mm. long. On *Selaria* roots.
 (Page 834).....**setariae**

[Genotype *Anoecia corni* (Fabricius).]

Fabricius, Systema Entomologia, p. 736, 1775.

For fuller description see Baker, A. C., Ent. News, Vol. 27, p. 359, 1916.

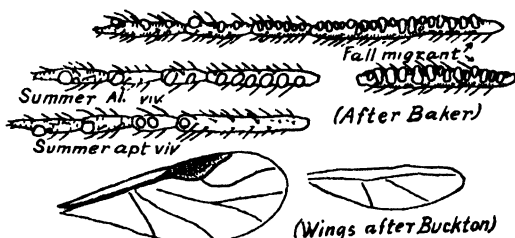


FIG. 3. *Anoecia corni*.

Color.—Brown to black in viviparae, alatae with anterior abdominal segments pale; legs dark.

Measurements.—Apterous vivipara.—Body 2 to 2.3 mm. long; joint III .32 to .35 mm.; IV .13 mm.; V .13 mm.; VI .13 + .05 to .06 mm. Alate vivipara, spring and summer form.—Same as aptera. Fall migrant.—Antennal joint III .46 to .51 mm.; IV .16 to .176 mm.; V .16 to .176 mm.; VI .14 to .176 + .064 mm.

Structural Characters.—Secondary sensoria oval to narrow transverse, 12 to 19 on III, 4 to 6 on IV and V in fall migrant; early summer migrant, 6 or 7 on III and oval. Hairs pointed and long. Rostrum attaining third coxae. Male apterous.

Hosts.—On *Svida* (Syn. *Cornus*), on leaves and twigs; and on *Gramineae*, on roots, also in ants' nests. Not recorded from Colorado. (Data from Baker, 1916, and Theobald, Aphid. Gr. Brit., Vol. 3, 1929.)

***Anoecia graminis* Gillette and Palmer.**

Gillette and Palmer, Ann. Ent. Soc. Amer. Vol. 17, p. 3, 1924.

Color.—Apterous viviparæ—Dull black with dusky bands; with slight pulverulence; appendages dark.

Measurements.—Apterous summer viviparæ.—Body 2 by 1.25 mm.; hind tibiæ .65 to .80 mm.; antennæ .65 to .80 mm.; joint III .21 mm.; IV .11 mm.; V .14 mm.; VI .16 + .05 mm.; cornicles .13 mm. in diameter at base of cone. Alate vivipara.—Same as aptera or slightly larger in all parts.

Structural Characters.—Secondary sensoria protruding, oval, 3 on III, 4 on IV and 4 on V in alata; in aptera 0 to 1 on III, 0 to 2 on IV, 0 to 3 on base of VI. Unguis slender and finger-like. Hairs on hind tibiæ, semi-erect to erect, moderately numerous, length .05 to .06 mm., about the same as diameter of tibiæ in aptera; in alata, .10 mm. long, nearly twice as long as diameter of tibia. Rostrum rather broad, barely attaining third coxæ. Oviparæ not showing hind tibiæ swollen or with sensoria.

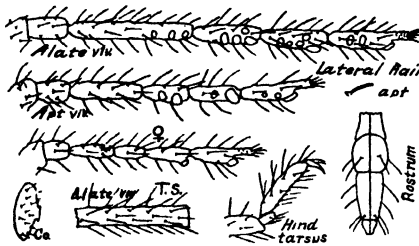


FIG. 4. *Anoecia graminis*.

Collections.—On *Hordeum* sp. on roots. Recorded from the state at Fort Collins and Cherokee Park; apterous summer viviparæ, Sept. 6 to 24; alate viviparæ, Sept. 13; oviparæ, Sept. 6, 16 and 24; 4 collections, 23 specimens; rare.

Taxonomy.—This species differs from *A. querci* (Fitch) in the lengths and sensoriation of the antennal joints, the more slender unguis, the color of the aptera and presence of oviparæ on grass roots.

***Anoecia querci* (Fitch).**

Fitch, Fifth Rept. Nox. & Ben. Ins., N. Y., p. 804, 1859. *Eriosoma*.

For fuller description see Baker, Ent. News, Vol. 27, p. 359, 1916.

Color.—Pale greenish or whitish to reddish-brown; with black bands and quadrate dorsal patch on abdomen in summer and fall alata; appendages black.

Measurements.—Apterous summer vivipara.*—Body 1.7 mm.—Antennal joint III, .13 mm.; IV .06 mm.; V .08 mm.; VI .096 + .048 mm. Alate vivipara.—Body 2 to 2.5 mm.; hind tibiae .7 to 1 mm.; hind tarsi .15 mm.; antennae .9 to 1 mm.; joint III .20 to .33 mm.; IV .08 to .12 mm.; V .09 to .12 mm.; VI .08 to .12 + .03 to .05 mm.; cornicle .17 mm. in diameter at base of shallow cone.

Structural Characters.—Secondary sensoria varying greatly in size, oval, almost circular, 0 to 8 on III, and 2 or 3 on IV, and V in fall migrant; in spring migrant 2 or 3 on III, or sometimes absent; absent in apteræ. Unguis stout and club-shaped. Hairs numerous, long and curved, covering antennæ and body. Rostrum attaining third coxæ. Mediæ once branched. Oviparæ not showing hind tibiae swollen or with sensoria. Males apterous, secondary sensoria not evident on antennæ.

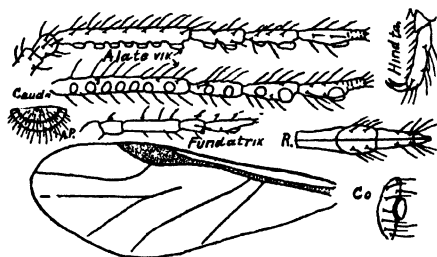


FIG. 5. *Anoecia querci*.

Collections.—On *Quercus*, *Svida stolonifera* (Syn. *Cornus*), on leaves and stems as winter host, and roots of grasses as summer host. Recorded from the state only on *Svida stolonifera*, at Fort Collins, Delta and Cherokee Park; fundatrices, April 25; apterous summer viviparæ not taken; alate viviparæ, Sept. 2 to Oct. 28; sexuales, Oct. 1 to 22; 17 collections; common.

Taxonomy.—This species has not been recorded in Colorado on its summer host, the grasses. This fact would seem to throw suspicion on the validity of the two species of *Anoecia*, namely *setariae* and *graminis* taken from grasses. The characters of these species seem, however, to be distinct. These three forms are accordingly held as distinct until further investigation proves otherwise.

***Anoecia setariae* Gillette and Palmer.**

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 17, p. 4, 1924.

Color.—In viviparæ pale-yellowish or greenish with slight dusky dashes dorsally and laterally.

*From description by Baker, (1916).

Measurements.—Apterous summer vivipara.—Body 1.9 mm.; hind tibiae .60 mm.; antennae .60 to .65 mm.; joint I .07 mm.; II .06 mm.; III .24 mm.; IV .09 mm.; V .11 mm.; VI .11 + .04 mm.; cornicles .12 mm. in diameter at base of cones. Alate vivipara.—Same as aptera or with slightly longer antennae and tibiae.

Structural Characters.—Secondary sensoria oval, strongly convex, 2 to 5 on III, 2 on IV and 1 on V in alate viviparae; absent in apterae. Unguis stout and finger-like to conical. Hairs pointed and fine on hind tibiae, drooping to semi-erect, .05 mm. long, hardly longer than diameter of tibiae in alatae. Rostrum rather slender and acute, attaining first abdominal segment. Many intermediate forms were taken.

Collections.—On *Setaria* sp., on roots. Recorded from the state at Fort Collins; apterous summer viviparae, Aug. 12 to Sept. 21; alate viviparae, July 21 to Sept. 21; 9 collections; rare.

Taxonomy.—This species is very close to *A. oenotherae* Wilson and may be identical, but has not been taken on *Oenothera* in Colorado. From *A. querci*, it differs in the absence of black dorsal patch on abdomen and fewer secondary sensoria in fall alate viviparae.



FIG. 6. *Anoecia setariae*.

Subtribe **Eulachnina**.

Structural Characters.—Body narrow and elongate, hardly broader than head. Eyes prominent, lacking tubercles. First joint of hind tarsi elongate, outer side .66 as long as inner side. Cornicles shallow, not on hairy cones. Rostrum obtuse. Unguis apparently bearing primary sensorium. Wings hyaline; radial sector straight, arising at lower distal angle of stigma. Living on needles of *Conifera*.

KEY TO GENERA OF EULACHNINA.

- A. Antennae 6-jointed, bearing long stout spines. **Eulachnus**
 AA. Antennae 5-jointed, bearing minute bristles or naked. (Page 838). . **Essigella**

Genus **Eulachnus** Del Guercio.

Type, *Lachnus agilis* Kalt. (Del Guercio, Rivista Patol. Vegetale, n. s., Vol. 3, p. 329, 1909).

Structural Characters.—As given for *Eulachnini*. Also antennae 6-jointed, primary sensorium proximal to unguis. Hairs are long stout spines. Mediae faint, usually once branched. Claws simple. Living on needles of *Pinus*.

[Genotype *Eulachnus agilis* (Kaltenbach).]

Kaltenbach, Mon. der Pflanzenlause, p. 161, 1843. *Lachnus*.

Color.—Apterous and alate viviparæ.—Pale green to yellowish with brown specks at bases of hairs; cornicles dusky; more or less pulverulent, legs yellowish-green.

Measurements.—Apterous vivipara.—Body 1.7 to 1.9 mm., narrow; legs long; antennæ not half the body in length; joints in following proportions; III, 60; IV, 35; V, 41; VI, 36; hind tibiæ 2 mm.; hind tarsi .47 mm. Alate vivipara.—Same as aptera.

Structural Characters.—Cornicles small elevated rings. Secondary sensoria of unequal size, 6 to 9 on III, and 0 to 4 on IV in alate viviparæ none in apteræ unless 1 on IV. Hairs long and bristle-like. Rostrum reaches second or third coxæ. Mediæ once forked. Males alate.

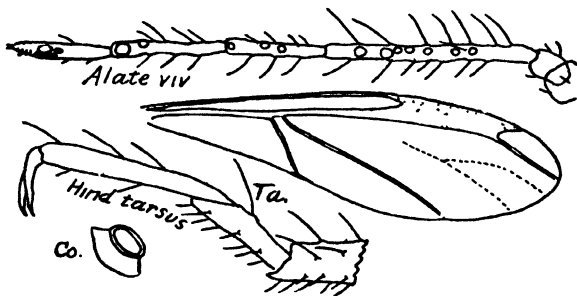


FIG. 7. *Eulachnus agilis*.

Collections.—On *Pinus sylvestris*, *halepensis*, and *pinaster*, on tender needles. [Data from Del Guercio, (1909) and Theobald, (Aph. Gr. Brit., Vol. 3, 1929).] Not recorded in Colorado.

Taxonomy.—This form is given as *L. agilis* Kalt. by Theobald (1929), Del Guercio (1909), Buckton (Mon. Br. Aphides, Vol. 3, 1881), Jackson (Scott. Nat., Sept. 1919), Mordvilko (Ann. d. Mus. Zool. Acad. Imp. Sci, 1908), and J. Davidson (Br. Aphides, 1925). Van der Goot (1915, Beit. z. Kenntid Holl. Blattlause, p. 389) describes a form which lacks secondary sensoria on antennal joint III in alate viviparæ. Kaltenbach did not note sensoriation in his descriptions.

Eulachnus rileyi (Williams).*

Williams, "Aphididae of Nebraska," Univ. Studies, Vol. 10, No. 2, p. 24, 1911.
Lachnus.

Color.—Olive-brown; somewhat powdery; cornicles black; legs dark.

*Listed as "*Lachnus near agilis*" by Gillette, 1909, Jo. Ent., Vol. 2, p. 385.

Measurements.—Apterous summer vivipara.—Body 2 to 2.6 by .6 mm.; hind tibiae 1.5 to 2 mm.; first joint of hind tarsi .08 mm. on outer side .11 mm. on inner side; second joint .21 mm.; antennae 1.2 mm.; joint III .42 to .50 mm.; IV .24 to .28 mm.; V .27 to .30 mm.; VI .13 to .17 + .04 to .06 mm.; cornicles mere rings without conical base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria absent in both alate and apterous viviparae, except 1 on IV. Unguis cylindrical or finger-like and blunt. Hairs heavy and spine-like, sparse on body, moderately numerous on appendages, on outside of hind tibiae, at angle of 45 degrees, .10 mm. long, more than twice as long as diameter of tibia in apterae; in alatae .08 to .12 mm.; twice, or more, as long as diameter of tibiae; hairs on inner side finer and shorter. Rostrum obtuse, attaining third coxae. Mediae faint, once forked, rarely simple. Males alate.

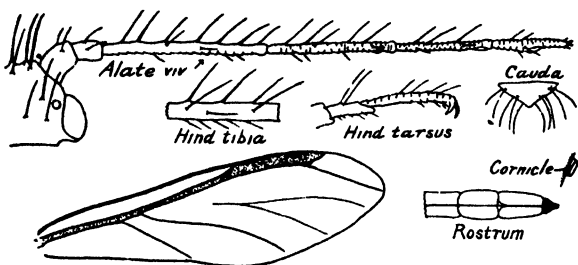


FIG. 8. *Eulachnus rileyi*.

Collections.—On *Pinus ponderosa* var. *scopulorum*, on needles. Taken in Colorado at Denver; apterous and alate summer viviparae, Sept. 10; sexuales, Oct. 7; 2 collections; rare or just being introduced; not taken in the wilds.

Taxonomy.—This species may be a synonym of *L. agilis* Kalt. but is determined as distinct on account of the absence of secondary sensoria on antennal joint III. These are reported present by Del Guercio (1909) and Kaltenbach (1843). Van der Goot (1915), however, reports none except on IV and slides sent us by him agree with this. No variation in this character is mentioned. Kaltenbach did not mention sensorial characters so it is impossible to decide which of these conditions is typical. It accordingly seems best to give our form the American name for the present.

Genus *Essigella* Del Guercio.

Type, *Lachnus californicus* Essig. (Del Guercio, Rivista Patol. Vegetale, n. s., Vol. 3, p. 329, 1909).

Characters.—Body elongate and narrow, parallel sided. Head much broader than long, eyes prominent, ocular tubercles absent. Antenna of five segments, bearing only a few minute bristles. Unguis bearing primary sensorium. Mediæ faint, once branched or simple. Rostrum broadly obtuse. Cornicles mere rings, not on hairy cones. Claws bifurcate. Living on needles of pines, especially between needles at bases; very quick and active.

Genotype, *Essigella californica* (Essig). (See below.)

KEY TO SPECIES OF *ESSIGELLA*.

- A. Tibial hairs* not longer than half of diameter of tibia. (Page 840) . *hoernerii*
- AA. Tibial hairs not shorter than diameter of tibia.
- B. Tibial hairs about same length as diameter of tibia. (Page 841) . *pini*
- BB. Tibial hairs much longer than diameter of tibia.
- C. Tibial hairs 1.5 to twice as long as diameter of tibia. Page (839) *fusca*
- CC. Tibial hairs distinctly longer than twice diameter of tibia. (Page 838), *californica*

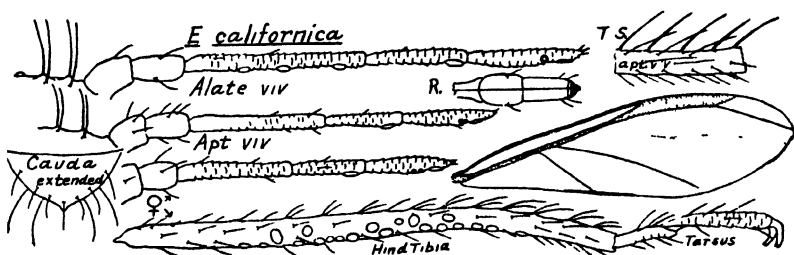


FIG. 9. *Essigella californica*.

[Genotype *Essigella californica* (Essig).]

Essig, Pom. Jour. Ent., Vol. 1, p. 1, 1909. *Lachnus*.

Color.—Alate and apterous viviparæ.—Pale green to yellowish, speckled with dusky at bases of hairs; with slight pulverulence; legs pale brownish or slightly dusky.

Measurements.—Apterous vivipara.—Body 2 by .6 mm.; hind tibiæ 1.2 mm.; first joint of hind tarsi .07 to .09 mm. on outer side, .10 to .12 mm. on inner side; second joint .20 mm.; antennæ .60 to .66 mm.; joint III .20 to .25 mm.; IV .11 to .14 mm.; V .08 + .05 mm.; cornicles mere rims, without mammiform base. Alate vivipara.—Body 2 to 2.2 by .50 mm.; hind tibiæ 1.3 to 1.9 mm.; first joint of hind tarsi .12 mm. on outer side, .16 mm. on inner side; second joint .25 mm.; antennæ .80 mm.; joint III .26 to .32 mm.; IV .15 to .17 mm.; V .12 + .04 to .05 mm.

*"Tibial hairs," wherever mentioned, refers to hairs on outer side of middle of hind tibiæ.

Structural Characters.—Secondary sensoria large, convex, not tuberculate, 2 to 4 on III, scattered along most of joint, absent on other joints; absent in apteræ. First and second pairs of tibiæ much shorter than hind pair. Hairs pointed on antennæ, .01 mm. long; on outside of hind tibiæ spine-like, at angle of 45 to 60 degrees, .09 to .10 mm. long, 2 to 3 times as long as diameter of tibia in apteræ; in alatae .10 to .12 mm., 3 to 4 times as long as diameter of tibia; on body slightly shorter and sparse; on vertex .06 to .07 mm. in apteræ, .08 to .09 mm. in alatae. Rostrum obtuse, attaining third pair of coxæ. Mediæ once branched. Males unknown.

Collections.—On *Pinus contorta* var. *murrayana*, rarely *scopulorum*, in tender tips on needles, near bases, solitary. Taken in the state in hills above Bellvue; fundatrices, May 24; apterous summer viviparæ, June 6 to 14 and Oct. 9; alate viviparæ, June 16 to Oct. 9; oviparæ, Oct. 2 to 9; 6 collections; seemingly rare.

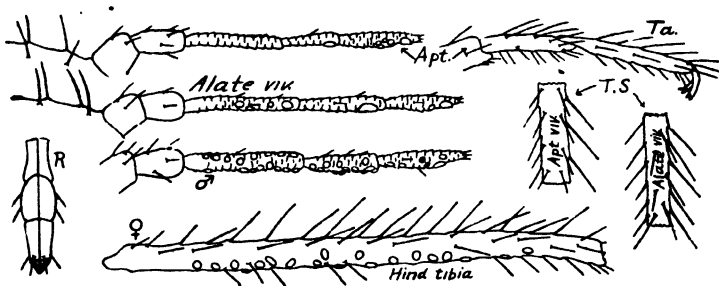


FIG. 10. *Essigella fusca*.

***Essigella fusca* Gillette and Palmer.**

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 17, p. 6, 1924.

Color.—Viviparæ.—Pale greenish or glaucous green, with dorsum marked with dusky spots often coalesced into bands or one solid patch fading out on head and pronotum; legs mostly dusky to blackish.

Measurements.—Apterous summer vivipara.—Body 2 to 2.2 mm. by .5 to .8 mm., parallel sided; hind tibiæ .8 to 1.15 mm.; first joint of hind tarsi .09 to .10 mm. on outer side, .12 to .13 mm. on inner side; second joint .18 to .20 mm.; antennæ .45 to .55 mm.; joint III .13 mm.; IV .07 to .09 mm.; V .07 to .08 + .03 to .09 mm. Alate vivipara.—Body 1.7 by .75 mm.; hind tibiæ 1.05 to 1.3 mm.; antennæ .57 mm.; joint III .15 to .23 mm.; IV .10 to .13 mm.; V .07 to .10 + .03 to .05 mm.

Structural Characters.—Cornicles mere rims without conical base. Secondary sensoria in alate viviparæ, 2 to 3 on III, none on IV or V; absent in apteræ. Unguis cylindrical blunt, bearing primary sensorium. Hairs slightly capitate; on hind tibiæ at angle of 45 to 60°, .06 to .08 mm.

long, 1.5 times as long as diameter of tibia in apteræ, about twice in alata; on antennæ .01 mm. long and sparse; on vertex .05 mm. long and pointed. Mediæ once branched, rarely simple. Rostrum attaining third coxæ. Males apterous.

Collections.—On *Pinus ponderosa* var. *scopulorum*, on needles at bases. Taken in Colorado near Estes Park, Bellvue, Log Cabin, Fort Collins, Denver and South St. Vrain Canon; fundatrices, May 8; apterous summer viviparæ, July 19 to Oct. 21; alate viviparæ, July 27 to Oct. 7; sexuales, Sept. 11 to Oct. 21; 14 collections; common but difficult to find on account of secluded location, protective coloration and agility in escaping.

Types in U. S. Nat. Mus., Cat. No. 41953; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species is distinguished from *E. californica* by the shorter tibial hairs and the dusky dorsal coloration in apteræ; from *E. pini* by the forked media, simple in only one wing in 23 examples.

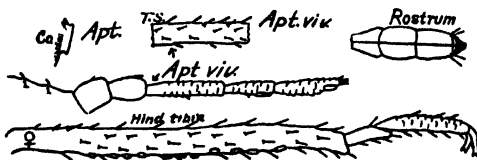


FIG. 11. *Essigella hoeneri*.

***Essigella hoeneri* Gillette and Palmer.**

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 17, p. 5, 1924.

Color.—Apterous viviparæ.—Apple-green posteriorly to yellowish anteriorly, without dusky spots at bases of hairs; legs pale.

Measurements.—Apterous vivipara.—Body 1.4 by .5 mm.; hind tibiæ .55 to .65 mm.; first joint of hind tarsi .06 mm. on outer side, .08 mm. on inner side; second joint .17 mm.; antennæ .42 mm.; joint III .11 to .13 mm.; IV .06 to .08 mm.; V .08 + .03 mm.

Structural Characters.—Cornicles mere rims without mammiform base. Secondary sensoria absent. Unguis cylindrical, blunt, bearing primary sensorium. Hairs slightly capitate, sparse, about .01 mm. long on outer side of hind tibia; almost invisible on antennæ, vertex and body, except posteriorly, where they are pointed and .05 mm. long. First and second pair of tibiæ somewhat thickened. Rostrum obtuse, attaining from third pair of coxæ to middle of abdomen. Alate viviparæ and males unknown.

Collections.—On *Pinus edulis* in abundance, rarely on *Pinus ponderosa* var. *scopulorum* and *Apinus flexilis*; on needles,

solitary. Taken in the state in Owl Canon in Larimer County; apterous summer viviparæ, Sept. 24 to Nov. 6; oviparæ, Oct. 27 to Nov. 6; 4 collections; abundant but difficult to find on account of solitary habits, small size, protective color and agility in escaping.

Types in U. S. Nat. Mus., Cat. No. 41952; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species is distinguished by the shortness of the tibial hairs and absence of dusky spots.

Essigella pini Wilson.

Wilson, Ent. News, Vol. 30, p. 6, 1919.

Color.—Viviparæ.—Pale greenish-yellow, with rows of dusky spots.

Measurements.—Apterous summer vivipara.—Body 1.6 to 2 by .45 mm.; hind tibiæ .70 to .95 mm.; first joint of hind tarsi .05 to .07 mm. on outer side, .10 to .12 mm. on inner side; second joint .17 to .20 mm.; antennæ .45 to .50 mm.; joint III .13 to .15 mm.; IV .07 to .10 mm.; V .09 + .03 to .05 mm. Alate vivipara not taken.



FIG. 12. *Essigella pini*.

Structural Characters.—Secondary sensoria absent in apteræ. Hairs slightly capitate on outer side of tibiæ at angle of 30 degrees; on hind tibiæ .03 to .04 mm. long, length equal to diameter of tibia, on vertex same as on tibiæ. Rostrum attaining first segment of abdomen.

Collections.—On *Pinus scopulorum*, rarely *contorta* var. *murrayana*, on bases of needles at tips of twigs. Taken in the state in foothills near Fort Collins, Bellvue, and Poudre Canon; fundatrix, May 24; apterous summer viviparæ, May 8 to Sept. 17; oviparæ, Oct. 13; 6 collections; rare.

Subtribe *Cinarina*.

Characters.—Usually large hairy forms, brown to black; often with pattern of white secretion. Cornicles usually on hairy cones. Rostrum lance-like. First joint of hind tarsus trapezoidal, outer side from .5 to .6 as long as inner side. Radial sector straight, almost reaching tip of wing. Ocular tubercles usually evident. Usually quick and spider-like in action. Living free on *Conifera*, on needles and bark of limbs and twigs.

KEY TO GENERA OF CINARINA.

- A. Rostrum obtuse. Mediae once branched or simple. (Page 842) *Schizolachnus*
- AA. Rostrum lance-like. Mediae once or twice branched. (Page 843)..... *Cinarina*

Genus *Schizolachnus* Mordvilko.

Type, *Aphis pineti* Fabricius (Syn. *Aphis tomentosus* Villers). Mordvilko, Ann. Mus. Zool. l'Acad. Imp. des Sci., St. Petersburg, Vol. 13, p. 375, 1908.

Characters.—Antennæ 6-jointed. Rostrum with terminal joints short, obtuse. Ocular tubercles inconspicuous. Mediæ with only one branch or simple. Living on needles of *Conifera*. Only one species known in the state.

Schizolachnus pini-radiatae (Davidson).*

Davidson, Jour. Econ. Ent. II, p. 299, 1909. *Lachnus*.

Color.—In all forms.—Dark olive-green to slaty brown; thickly covered with flocculent secretion; legs and antennæ dusky.

Measurements.—Apterous summer vivipara.—Body 2 to 2.5 mm.; hind tibiae 1.3 to 1.6 mm.; first joint of hind tarsi .05 mm. on outer

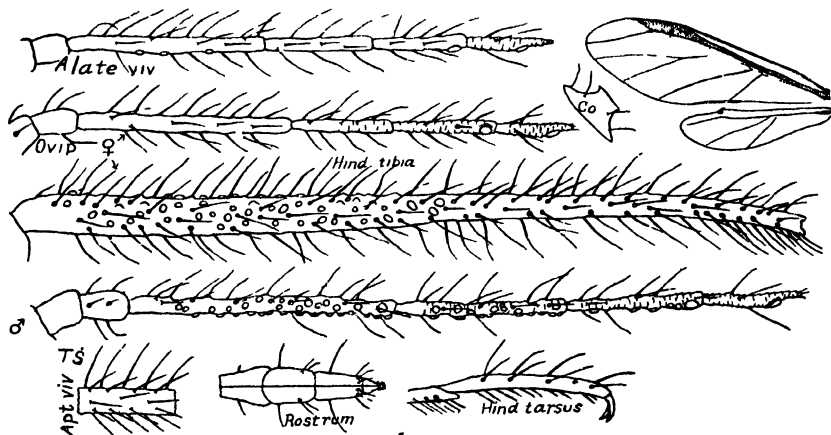


FIG. 13. *Schizolachnus pini-radiatae*.

side .09 mm. on inner side; second joint .30 to .37 mm.; antennæ 1.1 to 1.2 mm.; joint III .45 to .50 mm.; IV .22 to .28 mm.; V .20 to .24 mm.; VI .12 to .15 + .03 to .04 mm.; cornicles .12 to .15 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Cornicles mammiform, with flange, and bearing a few long hairs. Rostrum obtuse, attaining between second and third coxæ. Hairs attaining .15 to .18 mm. on outer side of hind

*This is the species published by Gillette (1917, Ann. Ent. Soc. Amer., Vol. 10, p. 140) as *Lachnus tomentosus*. Specimens determined as *L. tomentosus* sent by N. Cholodkovsky and P. Van der Goot are smaller in all measurements, hairs especially, and show the hind first tarsal joint as one-third of second, and Del Guercio's drawing ("Lacnidi Ital." Redia Vol. 5, fasc. 2, Tav. 14, fig. 128, 1909), is in accord with this. The Colorado examples show first joint as only one-fourth of the second. The European form also has 3 to 8 sensoria on antennal joint III of alate viviparae, while the Colorado form shows 0 to 3.

tibiæ, or over three times as long as diameter of tibiæ; on antennæ as long as twice diameter of antennal joints. Secondary sensoria round, 0 to 3 on III in alate viviparæ, absent in apteræ. Males alate. Mediæ usually twice forked but occasionally simple.

Collections.—On needles of *Pinus ponderosa* var. *scopulorum* and *contorta* var. *murrayana*. Recorded from the state in foothills about Fort Collins, Boulder, Livermore, Ouray, Colorado Springs, Denver, Estes Park, and Greeley; fundatrices, April 7 to May 22; apterous viviparæ, May 28 to Oct. 2; alate viviparæ, May 28 to July 18; oviparæ, Sept. 27 to Nov. 25; males, Sept. 27 to Oct. 23; 32 collections; common.

Taxonomy.—This form differs slightly from specimens in the collection of Stanford University taken on *Pinus radiata*. The differences are, slightly longer and stronger hairs and more numerous sensoria, 3 to 8 on antennal joint III in alate viviparæ of the California examples. These differences do not seem sufficiently distinct, considering the small number of specimens at present available, to justify the erection of a separate species. It also seems better to ally the Colorado form with the American species than with the more remote European form, though a more thorough study may prove all to be but races of the same species.

Genus *Cinara* Curtis.*

Type, *Aphis pini* Linnaeus, (Curtis, Brit. Entom. Sectn., 576, 1835).

Characters.—Body usually 3 to 5 mm. long and robust, bearing moderate to long, erect hairs. Color.—Brown or black, usually with more or less of a pattern of white secretion. Antennæ shorter than the body, 6-jointed, with unguis of VI shorter than half of base. Rostrum lance-like. Cornicles mere rings nearly always on a conical and hairy base. First tarsal joint distinctly trapezoidal, longer than broad. Wings hyaline; radial sector straight, arising from lower distal angle of stigma; media faint, usually twice but sometimes once forked; hind wings with both media and cubitus. Living on bark of twigs and limbs of *Conifera*.

Genotype, *Cinara pini* (Linnaeus). (See below.)

**Cinara* Curtis is here used for the genus which has heretofore been designated by the writers as *Lachnus* Burmeister. *Lachnus* Burmeister is here used to replace *Pterochlorus* Rondani. The writers have been forced to make this change on learning of the fact that *Lachnus fasciatus* Burmeister is a synonym of *A. roboris* L. (Schumacher, Zoo. Anz. 1921 and 2). *A. roboris* was the first type set for *Lachnus* but was considered invalid on account of not being included by Burmeister in his original description of the genus. *A. roboris* is now validated and *Pterochlorus* is a synonym of *Lachnus*. *Cinara* Curtis was published the same year as *Lachnus* with *Aphis pini* Linnaeus designated as type. According to rule this designation is valid regardless of mistaken identification by Curtis. For fuller discussion on this question see paper by F. C. Hottes (Pr. Bio. Soc. Wash., Vol. 43, p. 185-8, 1930).

KEY TO SPECIES OF CINARA.

- A. Cornicles not on distinct conical base. (Base very narrow if present and not raised). On *Pseudotsuga taxifolia*.
- B. Tibial hairs on hind tibiae* fine and numerous, especially on distal half of tibiae, very drooping. (Page 872).....*taxifoliae*
- BB. Tibial hairs rather spine-like, hardly numerous, and rather erect.
- C. Distal one-third or more of hind tibiae dark to black in live specimens. (Page 865).....*pseudotsugae*
- CC. Only tips of hind tibiae black in live specimens. (Page 871).....*splendens*
- AA. Cornicles on distinct conical base.
- B. Cornicle base bearing both long and short hairs. On *Pinus ponderosa*. (Page 870).....*solitaria*
- BB. Cornicles bearing only one kind of hairs.
- C. Hairs on dorsum of abdomen of apterae minute, hardly exceeding .02 mm. in length and very sparse or absent.
- D. Vertex only slightly convex.
- E. Hairs on antennae shorter than one-half the diameter of joint, very drooping. On *Pinus flexilis*. (Page 853).....*flexilis*
- EE. Hairs on antennae one-half to as long as the diameter of joint, at angle of 45 degrees. On *Pinus edulis*. (Page 847).....*atra*
- DD. Vertex strongly convex. On *Pinus scopulorum*. (Page 854).....*glabra*
- CC. Hairs on dorsum of abdomen of apterae distinctly more than .03 mm. in length.
- D. Tibial hairs in apterae not longer than diameter of tibia.
- E. Hind tarsi hardly equalling one-tenth length of hind tibiae. On *Abies lasiocarpa*. (Page 850).....*curvipes*
- EE. Hind tarsi one-tenth of length of tibiae or more.
- F. Joint IV of antenna 1.5 or more times joint VI with unguis.
- G. Tibial hairs over .05 mm. On *Pinus edulis*. (Page 851).....*edulis*
- GG. Tibial hairs not more than .05 mm.
- H. Tibial hairs stout and blunt. On *Picea parryana*. (Page 849).....*coloradensis*
- HH. Tibial hairs fine and pointed. On *Pinus ponderosa* var. *scopulorum*. (Page 868).....*schwarzii*
- FF. Joint IV of antennae not more than 1.25 times joint VI with unguis.
- G. Hairs on hind tibia very drooping, forming angle of 30 degrees or less. On *Pinus ponderosa* var. *scopulorum*. (Page 868), *schwarzii*
- GG. Hairs at angle of more than 30 degrees with tibia.
- H. Base of cornicles about .25 mm. in diameter. Color black. Without powder. On *Picea engelmanni*. (Page 857).....*hottesi*
- HH. Base of cornicles .30 mm. or over in diameter. Color brown. Powdery.
- I. Hairs rather sparse on outer margin of hind tibiae, even in alatae. Sensoria on joint III of alatae 5 to 7 in number.
- J. Joint III rarely more than .55 mm. in length. On *Pinus ponderosa* var. *scopulorum*. (Page 864) *ponderosae*
- JJ. Joint III rarely less than .55 mm. in length. On *Pinus murrayana*.
- K. Tibial hairs about .08 mm., semispinelike. (Page 859).....*medispinosa*
- KK. Tibial hairs not over .05 mm., spine-like. On *Pinus contorta* var. *murrayana*. (Page 848).....*brevispinosa*
- II. Hairs numerous on tibiae, especially in alatae.
- J. Hairs on tibiae of apterae hardly one-half as long as diameter of tibiae. On *Pinus flexilis*. (Page 846) *apini*

*"Tibial hairs," wherever herein mentioned, means hairs on outer side of middle of hind tibiae.

- JJ. Hairs on tibiae of apterae over one-half as long as diameter of tibiae. On *Pinus flexilis*. (Page 847),
apini var. *villosa*
- DD. Tibial hairs on hind tibiae in apterae once but less than twice as long as diameter of tibiae.
- E. Cornicle bases small, not over .20 mm. in diameter.
- F. Hind tibiae in apterae longer than one-half body. Rostrum much longer than body. On *Pinus murrayana*, on cones. (Page 862)..... *oregonensis*
- FF. Hind tibiae in apterae not longer than one-half body. Rostrum much longer than body.
- F'. On *Sabina scopulorum*. (Page 866)..... *pulverulens*
- FF'. On *Picea parryana*. (Page 854)..... *fornacula*
- EE. Cornicle base large, over .25 mm. in diameter.
- F. Tibial hairs at angle not exceeding 60 degrees.
- G. Hind tibiae fully .66 length of body. On *Pinus murrayana*. (Page 860)..... *murrayanae*
- GG. Hind tibiae less than .66 length of body.
- H. Body in apterae not less than 4 mm. in length. (Page 860),
lasiocarpae
- HH. Body in apterae not over 4 mm.
- I. Antennae of alate viviparae with 3-5 sensoria on joint III. Mediae twice branched. On *Picea parryana*. (Page 863)..... *palmerae*
- II. Antennae of alate viviparae with one sensorium on joint III. Mediae once branched. On *Juniperus sibirica*. (Page 858)..... *juniperensis*
- FF. Tibial hairs at an angle exceeding 60 degrees.
- G. Apterous viviparae, light or amber brown, with powdery markings. Males alate.
- H. Tibial hairs not numerous. On *Pinus edulis*. (Page 873),
terminalis
- HH. Tibial hairs numerous.
- I. Powdery markings distinct. Mediae twice branched. On *Picea parryana*. (Page 855)..... *glehna*
- II. Powdery markings indistinct. Media one branched. On *Picea engelmanni* (Page 852)..... *engelmanniensis*
- GG. Apterous viviparae without powder. Males apterous. On *Picea engelmanni* (Page 874)..... *vandykei*
- DDD. Tibial hairs on hind tibiae of apterae twice or more times as long as diameter of tibiae.
- E. Cornicle base small, .16 to .20 mm. in diameter. On *Abies lasiocarpa*. (Page 861)..... *occidentalis*
- EE. Cornicle base large, .30 mm. or more in diameter.
- G. Joint III of antenna exceeding sum of joints IV and V, hairs of hind tibiae, .17 to .25 mm. in length. On *Sabina scopulorum*. (Page 867)..... *sabinae*
- GG. Joint III of antenna shorter than the sum of joints IV and V, hairs of hind tibiae .14 to .17 mm. long. On *Juniperus sibirica*. (Page 869)..... *sibiricae*

[Genotype *Cinara pini* (Linnaeus).]

Linnaeus, Edition 10, Systema Naturae, p. 453, 1758. *Aphis*.

Color.—In both alate and apterous viviparae, reddish-brown with numerous dark specks, a pair of larger ones posterior to cornicles; with pattern of white pulverulence; legs yellowish-red to dusky; cornicles dark.

Measurements.—Apterous summer vivipara.—Body 3.5 to 4 mm.; antennae, hardly as long as head and thorax; joint III longest, about

equal to IV + V, IV longer than V, (shorter in photograph); VI equal to three-quarters of V; rostrum, attaining to or past third coxæ. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria round, and small, 7 to 9 in a row along almost entire length of III in alate viviparæ. Hairs long and numerous on all parts; on antennæ, nearly or quite twice as long as diameter of joints. Rostrum lance-like. [Data after Theobald (Aph. Gr. Br., Vol. 3, p. 145, 1929).]

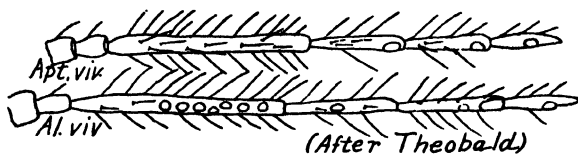


FIG. 14. *Cinara pini*.

Host.—On *Pinus sylvestris*.* Not known in the state, probably on account of scarcity of the host plant.

Cinara apini (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 31, 1924. *Lachnus*.

Color.—In all forms.—Dark brown; mottled with powder; legs and antennæ yellowish to dusky.

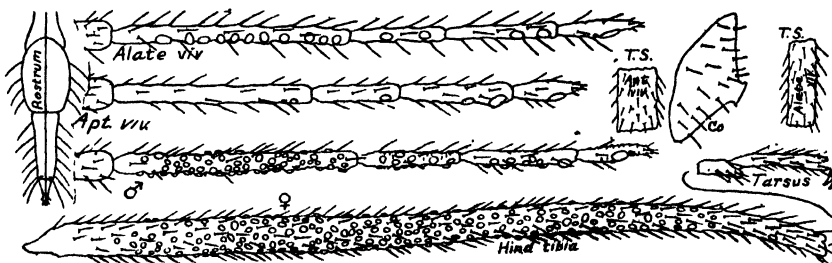


Fig. 15. *Cinara apini*.

Measurements.—Apterous summer vivipara.—Body 3.25 to 4 mm.; hind tibiae 2.5 to 3 mm.; hind tarsi first joint .06 on outer margin, .12 mm. on inner margin; second joint .26 mm.; antennæ 1.25 mm.; joint III .42 to .52 mm.; IV .16 to .23 mm.; V .22 to .26 mm.; VI .11 to .13 + .03 to .05 mm.; cornicle base .35 to .40 mm. in diameter. Alate vivipara.—Same as aptera. Unguis rather heavy and blunt conical.

Structural Characters.—Secondary sensoria round, convex, 8 to 11 on III, 2 on IV, and 1 on V in alate viviparæ; in apteræ 0 to 1 on III,

*Record on *Pinus scopulorum* in Colorado by Cowen (Gillette and Baker, "Hemiptera of Colorado," Agr. Exp. Sta. Bul. 31, 1905) is doubtless in error.

1 to 2 on IV, and 1 on V. Rostrum attaining at least middle of abdomen. Hairs tending to be spine-like, moderately numerous; on body .05 to .07 mm. long; on cornicles slightly longer; on hind tibiae set at angle of 30 to 45 degrees, .04 mm. long, in apteræ hardly as long as half diameter of tibiae; in alatae .06 to .07 mm., fully as long as diameter of tibiae. Mediae faint and twice forked. Males alate.

Collections.—On *Apinus flexilis* on bark of twigs and small branches; in large colonies. Quite sluggish and slow to escape. Recorded generally where the host plant occurs in the state; near Estes Park, Chambers Lake and Cherokee Park; apterous summer viviparæ, July 4 to Oct. 4; alate viviparæ, July 7 to Sept. 27; sexuales, Sept. 2 to Oct. 5; 9 collections, very common.

Types in U. S. Nat. Mus., Cat. No. 41964; paratypes in collection of Colo. Agr. Exp. Sta.

***Cinara apini* var. *villosa* n. var.**

Similar to *apini* excepting that the tibial hairs are longer, in the apteræ .06 mm., length over half diameter of tibia, and in the alatae .11 mm., once and one-half times diameter of tibia.



FIG. 16. *Cinara apini* var. *villosa*.

Taken in same localities and on same host as given above for *apini* but not observed mixed in the same colonies or on the same tree. This is the long-haired form referred to in the original description of *apini*. Fundatrices, June 30 to July 8; apterous summer viviparæ, July 12 to Aug. 27; alate viviparæ, July 26 to Aug. 9; 12 collections; common.

Types in U. S. Nat. Mus. Cat. No. 42811; paratypes in collection of Colo. Agr. Exp. Sta.

***Cinara atra* (Gillette and Palmer).**

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 37, 1924. *Lachnus*.

Color.—Shining black in all forms; no powder on dorsum; legs and antennæ yellowish to dusky.

Measurements.—Apterous summer vivipara.—Body 2 to 3 mm.; hind tibiae 1.3 to 1.8 mm.; hind tarsi, first joint .05 mm. on outer edge, .08 to .10 mm. on inner edge; second joint .25 to .28 mm.; antennæ 1.05 mm.; joint III .32 to .38 mm.; IV .15 to .17 mm.; V .20 mm.; VI .10 + .03 to .04 mm.; cornicle base .25 to .30 mm. in diameter.

Alate vivipara.—Same as aptera. Hairs drooping, set at angle of 30 degrees, medium in texture and hardly numerous, on outer side of hind tibiae, in alatae attaining .06 to .09 mm.; length equalling 1 to 1.5 times diameter of tibiae; in apterae, hairs on tibiae .04 to .06 mm. long, shorter than diameter of tibia; on body and cornicles .01 to .02 mm. long. Rostrum about same length as body.

Structural Characters.—Secondary sensoria absent in apterae or occasionally 1 on IV and V; in alate viviparae 4 to 7 on III, 1 to 2 on IV, and 1 on V. Unguis broadly conical. Mediae variable, either once or twice forked. Males apterous.

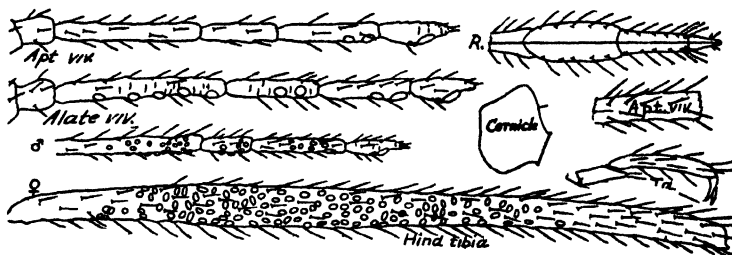


FIG. 17. *Cinara atra*.

Collections.—On *Pinus edulis*, on bark of limbs in small colonies, with ants. Recorded from the state in Owl Canon in Larimer County; apterous summer viviparae, Aug. 6 to Oct. 19; alate viviparae, Aug. 6; oviparae, Oct. 27 to Nov. 6; males, Oct. 6; 6 collections, fairly common.

Types in U. S. Nat. Mus., Cat. No. 41966; paratypes in collection of Colo. Agr. Exp. Sta.

Cinara brevispinosa (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 27, 1924. *Lachnus*.

Color.—In all forms.—Brown; mottled with dusky and with slight powder in apterae medially and laterally; alatae without powder; legs and antennae mostly dusky.

Measurements.—Apterous summer vivipara.—Body 3 mm.; hind tibiae 2 to 2.7 mm.; first joint of hind tarsi .05 mm. on outer side, .10 mm. on inner side; second joint .25 mm.; antennae 1.50 mm.; joint III .47 to .64 mm.; IV .20 to .26 mm.; V .20 to .30 mm.; VI .12 + .03 to .05 mm. Alate vivipara.—Same as aptera or slightly smaller.

Structural Characters.—Secondary sensoria in alate viviparae, 5 to 8 on III, 1 to 2 on IV, and 1 on V; in apterae 1 to 2 on III, 1 on IV, and 1 on V. Unguis heavy-conical. Rostrum attaining middle of abdomen. Mediae twice branched. Hairs blunt and stout, drooping, short, numerous, on outer side of hind tibiae, .05 mm. long, shorter than diameter of tibiae in alate viviparae; .04 mm. and about one-half diameter

in apterous viviparæ. Cornicles conspicuous, .30 to .45 mm. in diameter at base. Males alate.

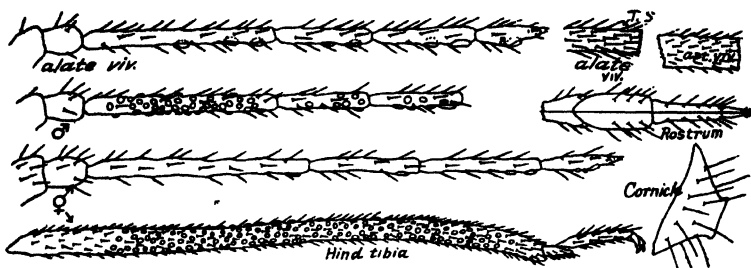


FIG. 18. *Cinara brevispinosa*.

Collections.—On *Pinus contorta* var. *murrayana*, on bark of twigs and small branches, in colonies. Recorded from the state in Rocky Mountain National Park, Chamber's Lake, Pingree Park, and Bellvue foothills; fundatrices, May 23 to June 13; apterous summer viviparæ, June 17 to Aug. 24; alate viviparæ, June 30 to July 17; sexuales, Aug. 21 to Oct. 2; 14 collections; rather common.

Types in U. S. Nat. Mus., Cat. No. 41962; paratypes in collection of Colo. Agr. Exp. Sta.

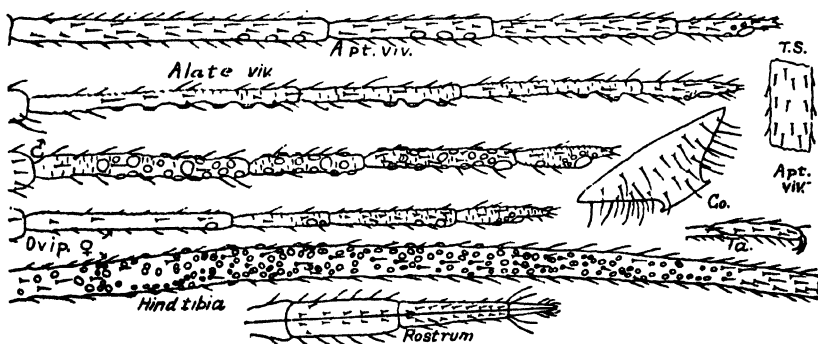


FIG. 19. *Cinara coloradensis*

Cinara coloradensis (Gillette).

Gillette, Ann. Ent. Soc. of Amer., Vol. 10, No. 2, p. 133, 1917. *Lachnus*.

Color.—In all forms.—Brownish-black, in apteræ lighter anteriorly, with little or no pulverulence, excepting tip of abdomen in oviparæ; legs brown to black.

Measurements.—Apterous summer vivipara.—Body 4 to 4.3 mm.; hind tibiae 3 mm.; first joint of hind tarsi .07 mm. on inner side, .14 mm. on outer side; second joint .33 mm.; antennae 1.6 to 2 mm.; joint III .40 to .75 mm.; IV .20 to .35 mm.; V .24 to .45 mm.; VI .12 to .15 + .04 to .06 mm.; cornicles .20 to .30 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria tuberculate in alate viviparae 7 to 8 on III, 1 to 3 on IV, and 2 on V at distal end of joints; in apterae, 1 to 5 on III, 1 to 2 on IV, and 0 on V. Rostrum attaining middle of abdomen. Mediae rather faint and twice forked. Hairs on hind tibiae short, .03 to .05 mm., usually blunt, stout, drooping, length equalling one-half diameter of tibiae in alatae, one-third in apterae, at angle not more than 30 degrees, moderately numerous; hairs on body pointed, slightly longer and erect. Males alate.

Collections.—On *Picea parryana* and *Engelmannii*, on bark of twigs and small branches; in colonies. Recorded from the state in vicinity of Loveland, Rocky Mountain National Park, (alt. 8000), Grand Junction (Alexander Lakes, 10,000) and Fort Collins; fundatrices, Apr. 20; apterous summer viviparae, June 6 to Sept. 1; alate viviparae, May 12 to Sept. 19; sexuales, Sept. 1 to Nov. 12; 14 collections; fairly common, especially in parks.

Types in U. S. Nat. Mus., Cat. No. 41941; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species is very closely allied to *C. curvipes* (Patch), differing in smaller size, smaller number and more distal location of secondary sensoria, hairs on hind tibiae more generally blunt, and hind tarsi more than one-tenth of tibiae, as well as the different genus of host plant.

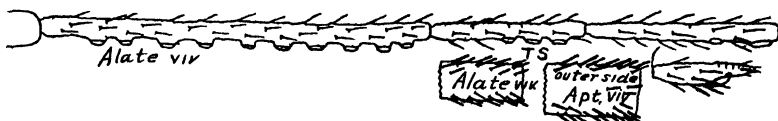


FIG. 20. *Cinara curvipes*.

***Cinara curvipes* (Patch).**

Patch, Me. Agr. Exp. Sta. Bul. 202, p. 161, 1912. *Lachnus*.

Color.—In all forms.—Brownish-black, with very little or no pulverulence, except tip of abdomen of oviparae; antennae pale; legs brown to black.

Measurements.—Apterous summer vivipara.—Body 5 mm. long; hind tibiae 3.5 to 4.6 mm.; first joint of hind tarsus .06 mm. on outer side, .15 mm. on inner side; second joint .38 mm.; antennae 2 to 2.2 mm.;

joint III .85 to .95 mm.; IV .26 to .36 mm.; V .30 to .45 mm.; VI .18 + .06 mm.; cornicles about .45 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria tuberculate in alate viviparæ 8 to 12 on III, 3 on IV, 1 on V; in apteræ 1 to 3 on III, 1 on IV, and 1 on V. Unguis conical and stout. Hind tibiæ distinctly curved. Hairs on hind tibiæ drooping, rather stout, often blunt, numerous, .04 to .05 mm. long, not longer than half diameter of tibiæ*; hairs on body pointed, .06 to .08 mm. and erect. Rostrum attaining middle of abdomen. Mediæ faint and twice forked. Males alate.

Collections.—On *Abies lasiocarpa*, on bark. Recorded in the state at Eldora, Ouray, and Rocky Mountain National Park; fundatrices, June 13 and 24; apterous summer viviparæ, June 24 to Aug. 28; alate viviparæ, July 8 to Aug. 28; oviparæ, Aug. 28; 8 collections; rare.

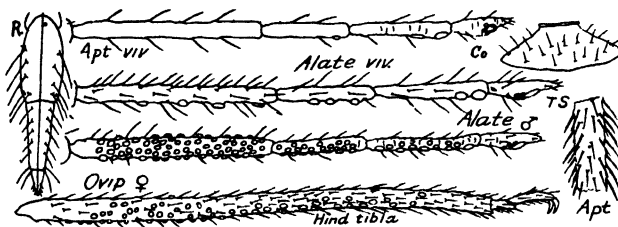


FIG. 21. *Cinara edulis*.

Cinara edulis (Wilson).

Wilson, The Can. Ent., Vol. 51, p. 41, 1919. *Lachnus*.

Color.—Dull black with fine median line and intersegmental patches powdery; legs mostly blackish, light portions orange-yellow.

Measurements.—Apterous summer vivipara.—Body 3 to 4 mm. long; hind tibiæ 2.5 to 3 mm.; first joint of hind tarsi .06 mm. on outer margin, .11 mm. on inner margin; second joint .26 mm.; antennæ 1.3 to 1.5 mm.; joint III .42 to .55 mm.; IV .22 to .30 mm.; V .20 to .30 mm.; VI .08 to .11 + .05 mm.; cornicles .35 to .50 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Hairs on hind tibiæ fine, pointed, at angle of 45 degrees, numerous, .08 mm. long, hardly as long as diameter of tibia; on body and cornicles about the same or slightly shorter. Secondary sensoria somewhat tuberculate, arranged in single row along distal two-thirds of joints, 3 to 6 on III, 2 to 3 on IV and 1 on V in alate

*In the same collections appear individuals, especially apteræ with pointed hairs as on body, but not as long as diameter of tibiæ. Perhaps the blunt hairs are broken, but this would be very strange considering the uniformity of the condition in certain individuals.

viviparæ; in apterous viviparæ 1, rarely 2 to 3 on III, 1 on IV and 1 on V. Unguis short and thick, conical. Rostrum attaining cornicles. Males alate.

Collections.—On *Pinus edulis*, bark of limbs and older twigs, in large colonies. Recorded in the state from Owl Canon in Larimer County, and Salida, Trinidad and Walsenburg; fundatrices, May 24 to June 8; apterous viviparæ, May 27 to Sept. 25; alate viviparæ, May 27 to Sept. 18; sexuales, Oct. 18 to 28; 12 collections; common.

Taxonomy.—This species is structurally very close to *C. schwarzii*, but differs slightly in color of legs and body markings, length of hairs, size of cornicles and food plant. Since it is the rule for this genus to be specific as to food plant, it seems best to count the species distinct until biological tests are applied to settle the identity.

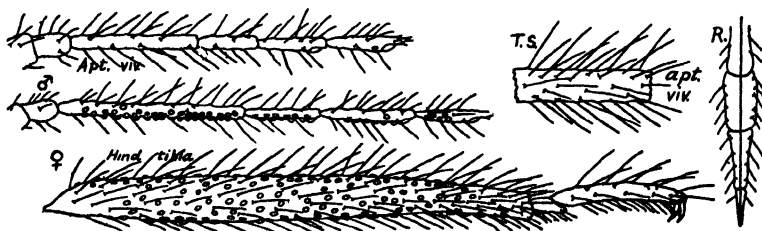


FIG. 22. *Cinara engelmanniensis*.

Cinara engelmanniensis (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 18, p. 526, 1925. *Lachnus*.

Color.—In viviparæ and oviparæ.—Light cinnamon-brown to tan or pinkish-buff; with a pair of longitudinal rows of green or black spots; in alate male, abdomen, apple green; pulverulence evident only on intersegmental lines; legs mostly pale especially in apteræ; cornicles brownish to dusky.

Measurements.—Apterous summer vivipara.—Body 3 mm. by 2 mm.; hind tibiæ 1.2 mm.; first joint of hind tarsi .05 mm. on outer edge, .09 on inner edge; second joint .35 mm.; antennæ, 1 mm.; joint III, .24 to .33 mm.; IV .10 to .16 mm.; V .13 to .18 + .03 mm.; cornicles .30 mm. in diameter at base.

Structural Characters.—Secondary sensoria absent in apteræ. Unguis short and stout, conical. Hairs on hind tibiæ rather fine, erect, numerous, .15 mm. long, 1.5 times as long as diameter of tibiæ; on body, .10 mm. long. Rostrum attaining first and second segments of abdomen. Mediæ once forked. Males alate.

Collections.—On *Picea engelmanni*, on bark of twigs in small colonies or scattered. Recorded in the state near Laramie-Poudre Tunnel, near Long's Peak, Pingree Park, and Black Mesa; apterous summer viviparæ, July 9 to Aug. 20; alate viviparæ not taken; oviparæ, Sept. 9 to Oct. 21; males, Sept. 3; 5 collections; rather rare.

Types in U. S. Nat. Mus., Cat. No. 41943; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—Resembles *C. braggii*, *glehna* and *farinosa*, but differs mainly in having very slight powder while the latter are heavily powdered to woolly, and in the once forked media which is twice forked in the others. Also the hind tibiæ are dusky only at tip, while many of these other species are dark for at least one-half.

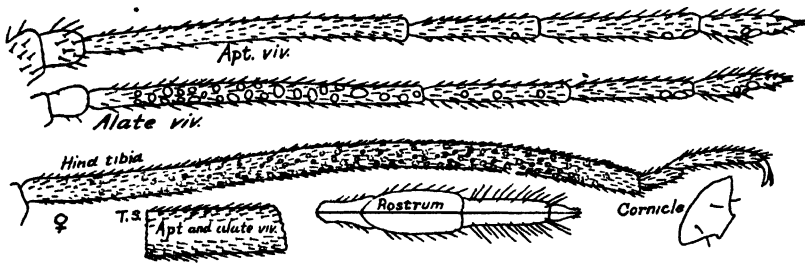


FIG. 23. *Cinara flexilis*.

***Cinara flexilis* (Gillette and Palmer).**

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 17, p. 30, 1924. *Lachnus*.

Color.—In all forms taken.—Brownish-black, greenish on thorax in younger examples; legs dusky orange to blackish.

Measurements.—Apterous summer vivipara.—Body 4 to 5 by 2 mm.; hind tibiæ 3.25 mm.; first joint of hind tarsi .16 mm. on outer side, .23 mm. on inner side; second joint .45 mm.; antennæ 2 mm.; joint III .78 to .90 mm.; IV .32 to .39 mm.; V .38 to .42 mm.; VI .18 + .08 mm.; cornicles .15 to .20 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Hairs on body .01 to .03 mm. long and sparse in some places, in others .04 to .08 mm. and numerous; on hind tibiæ pointed, decumbent, very numerous, .03 to .04 mm. long, not longer than one-third of diameter of tibiæ in aptera, one-third to one-half in alate viviparæ. Unguis heavy, cylindrical with conical tip. Secondary sensoria flat and irregular in size, scattered along almost entire length of joint, 17 to 25 on III, 3 on IV, and 1 on V in alate viviparæ, in apteræ 0 on III, 0 to 2 on IV and 1 on V. Rostrum rather

stout, attaining middle of abdomen. Mediæ faint, twice forked (only 2 alate collected). Very nervous and quick to escape. Males not taken.

Collections.—On *Apinus flexilis*, on bark of twigs and small branches; rather scattered, not in colonies. Recorded in the state near Estes Park; apterous summer viviparæ, July 22 to Aug. 18; alate viviparæ, July 22; oviparæ, Sept. 18 and 21; 4 collections; rare.

Types in U. S. Nat. Mus., Cat. No. 41963; paratypes in collection of Colo. Agr. Exp. Sta.

Cinara fornacula Hottes.

Hottes, Pr. Bio. Soc. Wash., Vol. 43, p. 186, 1930.

Color.—In apterous summer vivipara.—Light green; brownish on head, with brown spots on body; slightly pulverulent; legs mostly yellowish-brown.

Measurements.—Apterous summer vivipara.—Body 3 mm.; hind tibiæ 1.40 mm.; first joint of hind tarsi .05 mm. on outer side, .11 mm. on inner side; second joint .45 mm.; antennæ 1.05 mm.; joint III .35 mm.; IV .15 mm.; V .22 mm.; VI .17 + .04 mm.; cornicles .14 mm. in diameter at base.

Structural Characters.—Hairs on outer side of hind tibiæ spine-like, set at angle of 50 to 80 degrees, .08 to .11 mm. long, as long or slightly longer than the diameter of the tibia; on antennæ, slightly finer and shorter and about twice as long as diameter of joint; on body and cornicles, about same as on antennæ. Secondary sensoria absent. Cornicles with mammiform base, bearing but one kind of hairs. Rostrum lance-like, attaining second abdominal segment.

Collections.—On *Picea parrayana*, on twigs, solitary. Very active. Recorded from the state at Cameron Pass; apterous summer vivipara, Aug. 26; no other form taken; one collection; apparently very rare or exceedingly difficult to find.

Described from the single specimen taken by F. C. Hottes in northern Colorado and referred to by him in his original description.

Cinara glabra (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 35, 1924. *Lachnus*.

Color.—In all forms.—Dusky olive-green to olive-brown to black; without powder on dorsum; shining on head, remainder of dorsum wrinkled; legs mostly dusky, lighter parts orange-brown; wings slightly smoky, stigma and costal cell quite brownish.

Measurements.—Apterous summer vivipara.—Body 2.5 to 3 mm.; hind tibiæ 1.5 to 1.75 mm.; first joint of hind tarsi .06 mm. on outer

side, .10 mm. on inner side; second joint .26 mm.; antennæ 1.1 mm.; joint III .40 to .48 mm.; IV .14 to .24 mm.; V .18 to .20 mm.; VI .14 + .07 mm.; cornicles .15 to .20 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Hairs fairly numerous on tibiæ at angle of 45 degrees to nearly erect, .03 mm. to .05 mm. long, about as long as half of diameter of tibiæ in apterous viviparæ, nearly equal in alata; on dorsum sparse, minute, .01 mm. to .02 mm. long. Unguis stout, cylindrical with conical tip. Secondary sensoria flat, irregular in size located distally on joint, on III only, 4 in number in alate viviparæ; absent in apteræ. Rostrum slender, nearly as long as body. Vertex strongly convex, appearing rather pointed. Femora not thickened. Ocular tubercles plainly evident. Mediæ faint and twice forked. Males alate.

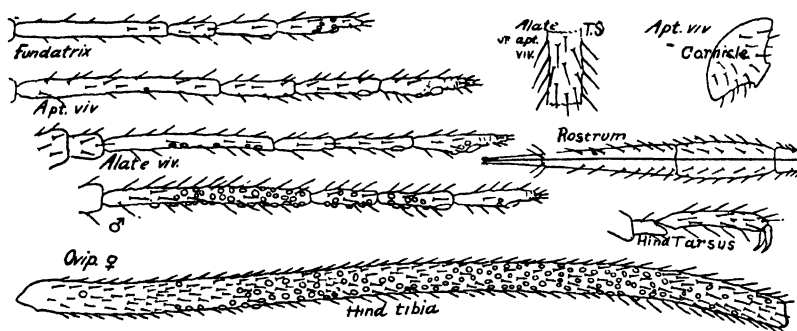


FIG. 24. *Cinara glabra*.

Collections.—On *Pinus scopulorum*, on twigs at bases of needles; solitary or in small colonies. Recorded in the state near Estes Park, Big Thompson Canon, Log Cabin, foothills about Fort Collins, Bellvue and Denver; fundatrices, May 11; apterous summer viviparæ, May 25 to Aug. 21; alate viviparæ rare, June 25 to Aug. 20; sexuales, Sept. 10 to Oct. 22; 17 collections; rather common.

Types in U. S. Nat. Mus., No. 41965; paratypes in collection of Colo. Agr. Exp. Sta.

Cinara glehna (Essig).

Essig, Jour. Ent. & Zool., Claremont, Cal., Vol. 7, p. 180, 1916. *Lachnus*.

Syn. Gillette, Ann. Ent. Soc. of Amer., Vol. 10, No. 2, p. 138, 1917. *Lachnus braggi*.

Color.—In all forms.—Yellowish with dark brown areas and almost entirely covered with white powder; legs and antennæ pale.

Measurements.—Apterous summer vivipara.—Body 3 to 4 mm.; hind tibiae 1.3 to 1.6 mm.; first joint of hind tarsi .06 mm. on outer margin, .10 mm. on inner margin; second joint .32 mm.; antennae 1 to 1.17 mm.; joint III .46 to .56 mm.; IV .18 to .21 mm.; V .18 to .28 mm.; VI .14 + .03 mm.; diameter of cornicles at base .20 to .30 mm., sometimes surrounding area to .40 or .50 mm. darkened but covered with powder in life to diameter of .14 mm. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria round, slightly convex, 1 to 4 on III, 1 on IV, and 2 on V in alatae; in apterae 0 on III, 1 or 2 on IV, and 2 on V, located on distal ends of joints. Hairs rather fine, erect, .15 to .17 mm. long, 1.5 as long as diameter of tibia in apterae, 2 to 3 times in alatae. Rostrum attaining third coxae. Males alate.

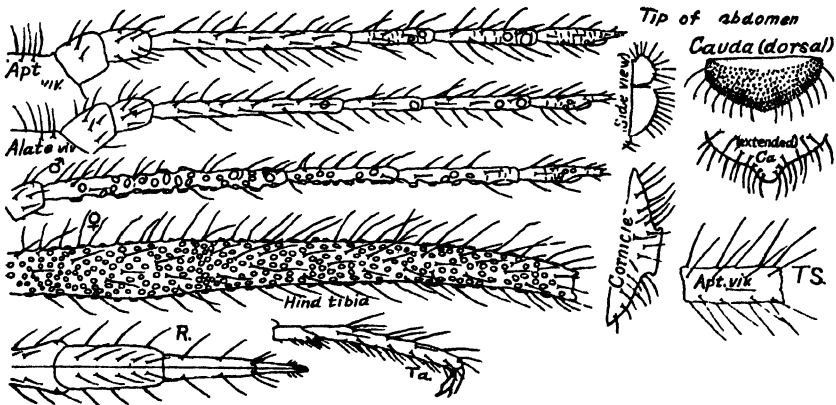


FIG. 25. *Cinara glehna*.

Collections.—On *Picea parryana* and *glehni*, on bark of twigs and small branches in colonies. Recorded in the state in vicinity of Boulder, Denver, and Fort Collins, but never in the hills; fundatrices, April 13 to 21; apterous summer viviparae, April 22 to June 22; alate viviparae, May 11 to June 22; sexuales, Oct. 23 to Nov. 13; 21 collections; rather common in parks.

Types of *braggii* in U. S. Nat. Mus., Cat. No. 41940; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—Resembles very much *C. farinosa* Cholod., and may be a synonym, but mediae in all our examples are twice forked, while in *farinosa*, they are once forked according to P. Van der Goot's description, (Beit. z. Kenntid, Holl. Blattlause, p. 389, 1915). The authors have not had access to Cholodkovsky's description (Rev. Sci. Nat. St. Petersburg, No. 8, 1891), so are unable to definitely decide the question.

***Cinara hottesi* (Gillette and Palmer).**

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 17, p. 22, 1924. *Lachnus*.

Color.—In all forms.—Bluish-black, with no pulverulence; legs conspicuously yellow.

Measurements.—Apterous vivipara.—Body 2.8 to 3.5 mm. long, pyriform; hind tibiae 1.7 to 2.5 mm.; first joint of hind tarsi .06 mm. on outer margin, 11 mm. on inner margin; second joint .28 mm.; antennae 1.55 to 1.6 mm.; joint III .55 to .60 mm.; IV .25 mm.; V .25 to .28 mm.; VI .11 to .16 + .05 to .07 mm.; cornicles .55 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria in alate vivipara convex, located distally, on III 3 to 5, on IV 0 to 1, on V 0 to 1; in apterous vivipara 0 to 1 on III, 2 to 3 on IV, 1 to 2 on V. Unguis conical, rather acute. Hairs on hind tibiae numerous, set at angle of 45 degrees, .08 mm. long, slightly longer than diameter of tibiae in apterae, 1.5 times in alatae; on body and antennae, .10 mm. long. Rostrum about as long as the body. Mediae twice forked and faint.

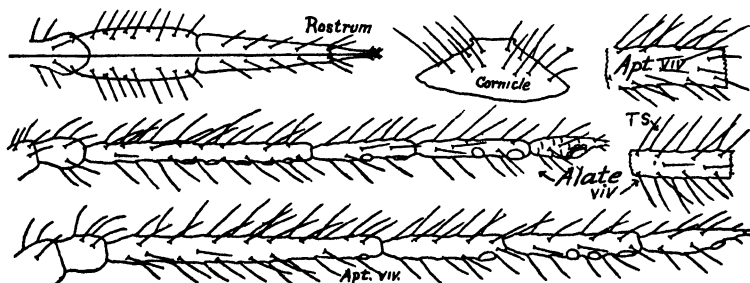


FIG. 26. *Cinara hottesi*.

Collections.—On *Picea engelmannii* on bark of young limbs. Recorded in the state in Rocky Mountain National Park; fundatrices, June 13; apterous summer viviparae (reared in insectary from fundatrices above-mentioned), July 8; alate vivipara (reared with apterae above mentioned) July 17; sexuales not taken; only one collection in nature; rare.

Types in U. S. Nat. Mus., Cat. No. 41959; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species seems to approach *C. curvipes* (Patch) but differs in longer hairs, fewer sensoria and light yellow legs.

***Cinara juniperensis* (Gillette and Palmer).**

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 18, p. 526, 1925. *Lachnus*.

Color.—In all forms taken.—Light greenish-brown to dark brown; with slight pulverulence, especially on intersegmental lines and lateral areas, tip of abdomen of ovipara heavily covered; cornicles black; legs considerably black with yellowish proximally.

Measurements.—Alate vivipara.—Body 4 mm. long; hind tibiae 3.2 mm.; first joint of hind tarsi .05 mm. on outer edge, .12 mm. on inner edge; second joint .44 mm.; antennae 1.75 mm.; joint III .56 to .60 mm.; IV .27 mm.; V .30 to .34 mm.; VI, .23 + .03 mm.; cornicles about .40 mm. in diameter at base.

Structural Characters.—Secondary sensoria convex but not tuberculate, in alate viviparae, 1 on III, 1 on IV, and 1 on V; oviparae same as alate viviparae. Unguis short, conical. Hairs on outer side of hind tibiae pointed, set at angle slightly exceeding 45 degrees, numerous, .13 mm. long, 1.5 times as long as diameter of tibia in alatae and oviparae. Rostrum broadly acute, attaining middle of abdomen. Mediae once branched (only 2 alatae taken).

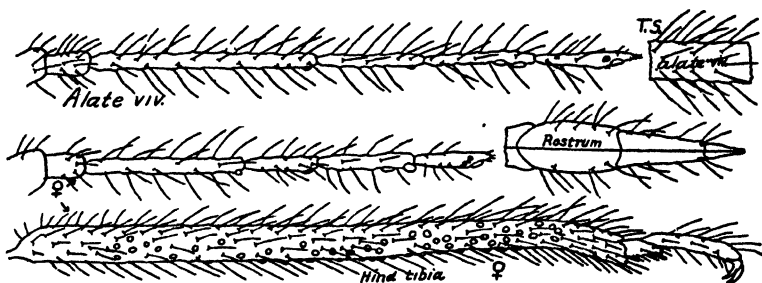


FIG. 27. *Cinara juniperensis*.

Collections.—On *Juniperus sibirica* on bark of tender twigs. Recorded in the state in Pingree Park and Rocky Mountain National Park; alate viviparae, Aug. 20; oviparae, Aug. 24; 2 collections; very rare.

Types in U. S. Nat. Mus., Cat. No. 41944; paratypes in collection of Colo. Agr. Exp. Sta.

***Cinara lasiocarpae* (Gillette and Palmer).**

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 23, p. 543, 1930. *Lachnus*.

Color.—Apterous viviparae.—Reddish to dark brown, mottled with broken pattern of white pulverulence; legs almost entirely black.

Measurements.—Apterous summer vivipara.—Body 4 to 5 mm. long, robust; hind tibiae 3.5 mm.; first joint of hind tarsi .04 mm. on outer side, .12 mm. on inner side; second joint .42 to .50 mm.; antennae

2 mm.; joint III .80 to .90 mm.; IV .34 to .44 mm.; V .40 to .45 mm.; VI .21 to .25 + .04 to .07 mm.; cornicles .30 to .50 mm. in diameter at

Structural Characters.—Secondary sensoria convex, slightly tuberculate, 0 on III, 2 to 3 on IV; 2 to 3 on V in apteræ. Unguis conical, acute, slender. Hairs pointed and spine-like, set at angle of 50 degrees, .14 to .16 mm. long, longer than diameter of tibiæ. Rostrum attaining cornicles.

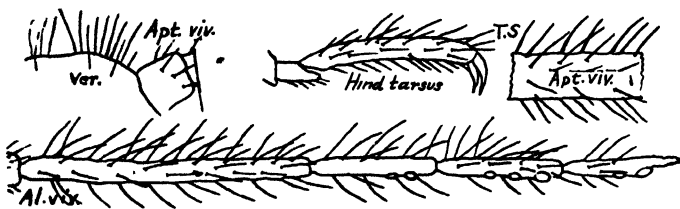


FIG. 28. *Cinara lasiocarpae*.

Collections.—On *Abies lasiocarpa*, on bark of twigs. Recorded in the state in Rocky Mountain National Park along Fall River, Black Mesa, and Rabbit Ears Pass; fundatrices, July 7 and 22 (altitude 9000 and 10,000 ft.); apterous summer viviparæ, July 7 to Aug. 12; alatae and sexuales not taken; 5 collections; rare.

Types in U. S. Nat. Mus., Cat. No. 42082; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species appears to be very closely allied to *Cinara grossa* (Kaltenbach) but differs from examples determined *grossa* and kindly sent by Cholodkovsky, in longer antennal joints, especially joint IV, and longer tarsi. (See original description of *lasiocarpae*).

***Cinara medispinosa* (Gillette and Palmer).**

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 22, p. 30, 1929. *Lachnus*.

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 23, 1924. *Lachnus similis*.

Color.—In all forms.—Yellowish-brown to dark metallic brown with slight pulverulence on median line and lateral areas, also on tip of abdomen in oviparæ; marked with broken black dashes on dorsum, medially and laterally, more pronounced anteriorly; legs mostly black.

Measurements.—Apterous summer vivipara.—Body 3 mm.; hind tibiæ 2.15 to 2.7 mm.; first joint of hind tarsi .05 mm. on outer side, .11 mm. on inner side; second joint .28 mm.; antennæ 1.5 mm.; joint III .53 to .68 mm.; IV .20 to .27 mm.; V .20 to .30 mm.; VI .10 to .13 + .03

to .05 mm.; cornicles .55 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria in alate viviparæ 5 to 8 on III, 1 to 2 on IV and 1 on V.; in apteræ 1 to 2 on III, 1 on IV and 1 on V. Unguis stout, conical. Hairs on hind tibiæ, semi-spine-like to fine, set at angle of 45 degrees, numerous, .07 to .08 mm. long, shorter than diameter of tibiæ in apteræ, slightly longer in alata; hairs on body and antenna about the same as on tibiæ; on cornicles .10 mm. Rostrum attaining middle of abdomen. Mediæ twice forked. Males alate.

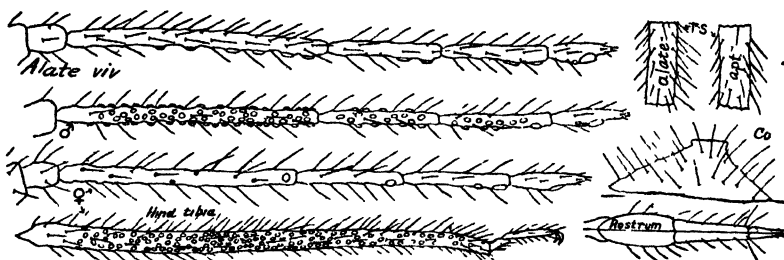


FIG. 29. *Cinara medispinosa*.

Collections.—On *Pinus contorta* var. *murrayana* on bark of tender twigs and young branches. Recorded in the state in foothills near Bellvue, Laramie-Poudre Tunnel, Pingree Park, and Tolland; fundatrices, May 9 to June 8; apterous summer viviparæ, May 31 to Sept. 16; alate viviparæ, May 31 to June 17; sexuales, Oct. 2 to Oct. 19; 14 collections; rather common.

Types in U. S. Nat. Mus., Cat. No. 41961; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species differs from *C. brevispinosa* chiefly in length of hairs, slightly larger measurements and larger number of sensoria. The two forms grade very close together but evidence from breeding observations seems to indicate separate identity. (See original description p. 39.)

Cinara murrayanae (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 26, 1924. *Lachnus*.

Characters.—Color same as *C. medispinosa* and measurements differing only in slightly larger size. The only distinguishing character is the heavier, more erect, and longer hairs. Hairs on hind tibiæ set at angle of 45 degrees to nearly erect, .10 to .15 mm. long, somewhat

longer than diameter of tibiae in apterae, and almost twice in the alatae; on antennae about .10 to .11 mm. long. Other characters as in *medispinosa* described above.

Collections.—On *Pinus contorta*, on bark of twigs and small branches. Recorded in the state in foothills above Bellvue; fundatrices, May 20; apterous summer viviparae, June 3 to June 12; alate viviparae, June 3; sexuales, Oct. 2 to 9; 5 collections; rare.

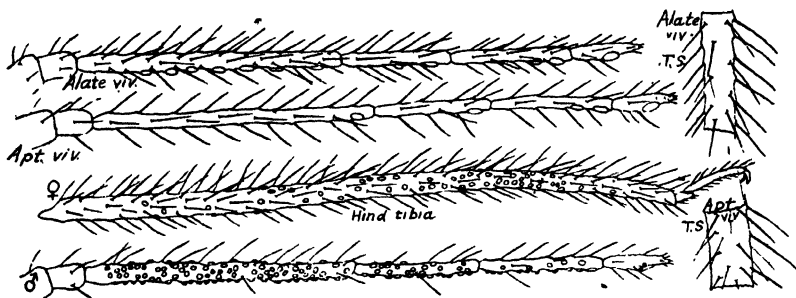


FIG. 30. *Cinara murrayanae*.

Types in U. S. Nat. Mus., Cat. No. 41960; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species is very close to *C. medispinosa* described above. The only apparent difference is in the longer, stouter and more erect hairs. Breeding experiments lend support to the separate identity of the two forms. (See original description and p. 29 of same article.)

***Cinara occidentalis* (Davidson).**

Davidson, Jour. Econ. Ent., II, p. 300, 1909. *Lachnus*.

Color.—In all forms.—Yellowish olive-green to greenish-brown, with a pair of longitudinal rows of dark areas, which tend to vanish on middle of abdomen; covered with flocculent pulverulence; cornicles, antennae, legs, stigma and subcostal vein, pale.

Measurements.—Apterous summer vivipara.—Body 2 to 3 mm.; hind tibiae 1.1 to 1.3 mm.; first joint of hind tarsi .02 mm. on outer side, .06 mm. on inner side; second joint .32 mm.; antennae 1 to 1.1 mm.; joint III .30 to .35 mm.; IV .12 to .17 mm.; V .15 to .20 mm.; VI .13 to .15 + .03 to .04 mm.; cornicles .15 to .17 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria small, on III, 1 to 3; on IV 2 to 3; on V 0; absent in apterae. Unguis slender, conical. Hairs on hind tibiae fine, nearly or quite erect, fairly numerous, .18 to .22

mm. long, 3 times the diameter of the tibia in alatae, 2 to 3 times in apterae; on body and antennae .10 mm. long. Rostrum attaining second abdominal segment. Mediae very faint and usually twice forked but occasionally once forked. Males alate.

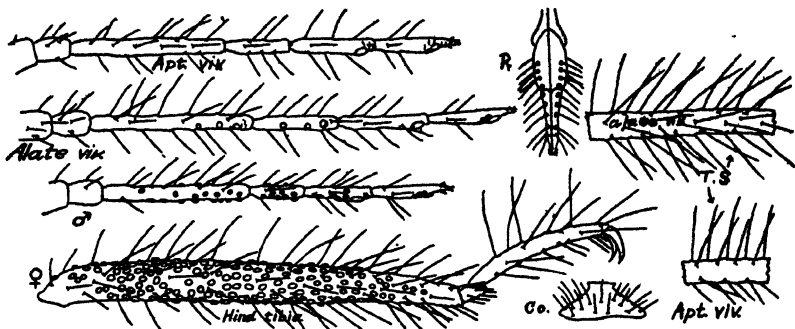


FIG. 31. *Cinara occidentalis*.

Collections.—On *Abies lasiocarpa*, on bark of twigs, eggs laid on needles. Recorded in the state near Laramie-Poudre Tunnel, Rocky Mountain National Park, and foot of Long's Peak; fundatrices, May 20 to July 7; apterous summer viviparae, June 14 to Sept. 16; alate viviparae, June 10 to Sept. 16; sexuales, Sept. 16 to Oct. 21; 14 collections; common.

Cinara oregonensis (Wilson).

Wilson, Trans. Amer. Ent. Soc. XLI, p. 103, 1915. *Lachnus*.

Color.—In all forms.—Brick-red, shining; slightly pulverulent on thorax of alatae, young, and sexuales, especially tip of abdomen of

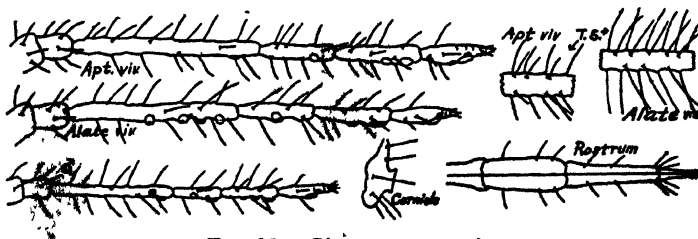


FIG. 32. *Cinara oregonensis*.

oviparae; legs and antennae yellow-brown to dusky; cornicles somewhat dusky.

Measurements.—Apterous summer vivipara.—Body 2.5 to 3 mm. long; hind tibiae 1.6 to 2 mm.; first joint of hind tarsi .04 mm. on outer

side, .08 mm. on inner side; second joint .27 to .30 mm.; antennæ .80 to 1 mm.; joint III .30 to .40 mm.; IV .10 to .16 mm.; V .12 to .19 mm.; VI .10 to .13 + .04 mm.; cornicles .10 to .15 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria large, convex, slightly tuberculate, 2 to 6 on III, 0 to 2 on IV; 0 to 1 on V in alate viviparæ, in apteræ 0 to 1 on III, IV and V each. Unguis bluntly conical. Hairs on hind tibiæ fine, fairly numerous, erect, .09 to .11 mm. long, 1.5 times as long as diameter of tibia in apteræ, twice in alata; on antenna, body and cornicles .05 to .07 mm. long. Rostrum as long as body or distinctly longer. Mediæ faint and twice branched. Oviparæ show no swelling of hind tibiæ and no evident sensoria. Males usually apterous but occasionally alate, and with but 2 secondary sensoria on joints III, IV and V, each.

Collections.—On *Pinus contorta* var. *murrayana*, once on *Pinus ponderosa* var. *scopulorum* on young cones, the second generation. all acquiring wings and migrating to the young cones. Eggs laid on cones. Recorded in the state at Eldora, hills above Bellvue, and Rocky Mountain National Park; fundatrices, May 13; apterous summer viviparæ, June 16 to Aug. 25; alate viviparæ, June 5 to 25; sexuales, Sept. 15 to Oct. 2; 12 collections; rare.

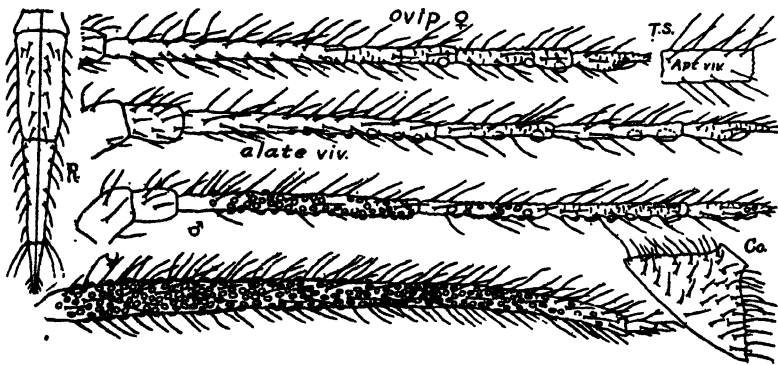


FIG. 33. *Cinara palmerae*.

Cinara palmerae (Gillette).

Gillette, Ann. Ent. Soc. Amer., Vol. 10, p. 135, 1917. *Lachnus*.

Color.—In all forms—Dark brown, with broken pattern of pulverulence, tip of abdomen of oviparæ heavily pulverulent; legs about half dusky and half pale yellow. Cornicles black.

Measurements.—Apterous summer vivipara.—Body 3.5 to 4 mm. long; hind tibiæ 2.2 to 2.5 mm.; first joint of hind tarsi .06 mm. on

outer side, .11 mm. on inner side; second joint .26 to .30 mm.; antennæ 1.3 to 1.5 mm.; joint III .45 to .54 mm.; IV .20 to .30 mm.; V .23 to .31 mm.; VI .15 + .03 to .04 mm.; cornicles .40 to .60 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria very slightly tuberculate on III, 3 to 5; on IV 1 to 3; on V 2 to 3, in alate vivipara; in aptera with 1 on III, IV and V each. Unguis conical. Hairs pointed, fine, numerous, set at angle of 45 degrees, .12 to .17 mm. long, over 1.5 times diameter of tibia in aptera, about twice in alata. Rostrum surpassing cornicles. Mediæ twice forked. Males alate.

Collections.—On *Picea parryana* and *engelmannii*, on bark of twigs and small branches, in large colonies. Eggs laid on bark of twigs mostly, a few on needles. Recorded in the state at Fort Collins, Paonia, and Tolland; fundatrices, March 16 to May 20; apterous summer viviparae, May 16 to July 20; alate viviparae, May 5 to Nov. 5; sexuales, Oct. 6 to Nov. 5; 25 collections; common in parks.

Types in U. S. Nat. Mus., Cat. No. 41942; paratypes in collection of Colo. Agr. Exp. Sta.

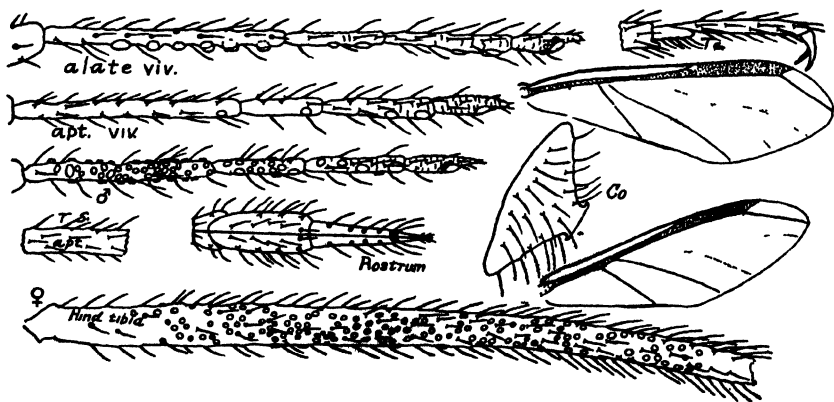


FIG. 34. *Cinara ponderosae*.

***Cinara ponderosae* (Williams).**

Williams, "Aphididae of Nebraska," Univ. Studies, Vol. 10, No. 2, p. 22, 1911.
Lachnus

Color.—In all forms.—Metallic golden-brown, with tendency to a pair of dorsal and lateral longitudinal rows of black areas; with broken pattern of white pulverulence; cornicles black; legs mostly black, partly yellow.

Measurements.—Apterous summer vivipara.—Body 2.5 to 4 mm. long; hind tibiae 2 to 2.75 mm.; first joint of hind tarsi .04 mm. on

outer side, .10 mm. on inner side; second joint .30 mm. long; antennæ 1.17 mm.; joint III .46 to .54 mm.; IV .16 to .20 mm.; V .21 to .28 mm.; VI .12 + .04 to .06 mm.; cornicles .55 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria convex, somewhat tuberculate, 1 to 4 on III, 1 to 2 on IV, 1 on V in alate vivipara; in aptera 1 to 2 on III, 1 on IV, 1 on V, located distally. Unguis conical, short, and thick. Hairs on hind tibiæ pointed, spine-like, rather sparse, set at angle of 45 degrees, .05 mm. long, slightly shorter than diameter of tibia in aptera; in alata .07 to .09 mm. slightly longer than diameter of tibia; on body and cornicles same as on tibiæ. Rostrum attaining or surpassing middle of abdomen. Mediæ faint and usually twice forked, rarely once forked. Males alate.

Collections.—On *Pinus ponderosa* var. *scopulorum* on bark of twigs and small branches in large colonies; eggs laid on needles. Recorded in the state in foothills of eastern slope of Rocky Mountains of Colorado; fundatrices, March 19 to May 2; apterous summer viviparæ, April 11 to Oct. 10; alate viviparæ, April 11 to Oct. 9; sexuales, Oct. 7 to Nov. 25; 39 collections; very common.

Taxonomy.—The specimens named *Lachnus pini* (L.) by Cowen ("Hemiptera of Colorado" Agr. Exp. Sta. Bul. No. 31, p. 117, 1895) were undoubtedly this species.

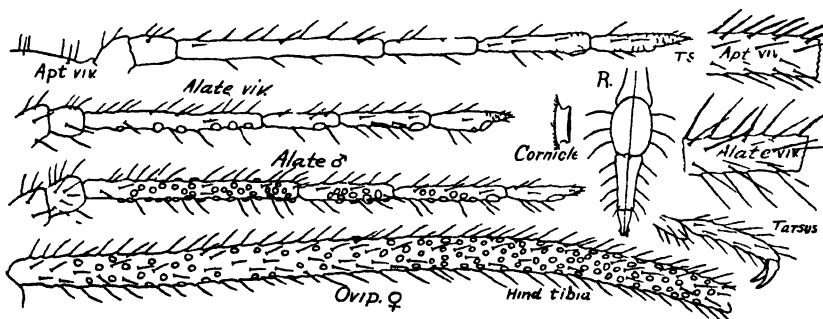


FIG. 35. *Cinara pseudotsugae*.

Cinara pseudotsugae (Wilson).

Wilson, Can. Ent. XLIV, p. 302, 1912. *Lachnus*.

Color.—In all forms.—Pale brownish shading to whitish medially, often tinged with green and with faint dusky dashes, fundatrices and oviparæ darker; with broken pattern of slight pulverulence; legs mostly dusky.

Measurements.—Apterous summer vivipara.—Body 3 mm. long; hind tibiæ 2 mm.; first joint of hind tarsi .05 mm. on outer side, .10 mm.

on inner side; second joint .36 mm.; antennæ 1 and 1.1 mm.; joint III .35 to .42 mm.; IV .15 to .18 mm.; V .18 to .21 mm.; VI .12 + .04 mm.; cornicles hardly more than mere rims, mammiform base rudimentary or absent. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria on joint III 2 to 7; on IV 1 to 2; on V 0; absent in aptera. Unguis conical, stout. Hairs on hind tibiæ, rather stout, pointed, numerous, set at angle of 45 to 60 degrees, .07 to .10 mm. long, hardly as long as diameter of tibia in aptera; .10 to .12 mm. in alata, 1 to 1.5 times as long as diameter of tibia; on antennæ and body finer, .04 to .05 mm. long. Rostrum attaining second or third coxæ. Mediæ twice branched. Males alate.

Collections.—On *Pseudotsuga taxifolia*, on bark of twigs; eggs laid on needles. Recorded in the state near Estes Park, Bellvue and Glen Haven; fundatrices, June 3 to 27; summer apterous viviparæ, June 16 to July 6, and Sept. 1; alate viviparæ, June 20 to Sept. 26; sexuales, Sept. 8 to 27; 9 collections; not common.

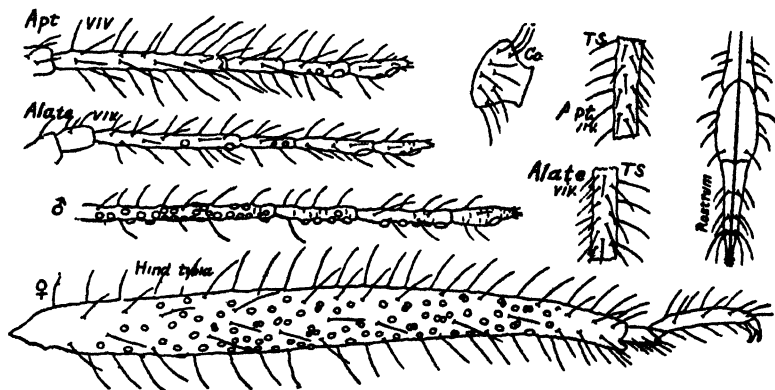


FIG. 86. *Cinara pulverulens*.

Cinara pulverulens (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 17, p. 40, 1924. *Lachnus*.

Color.—In all forms.—Yellowish-brown, with a pair of longitudinal rows of black areas, vanishing posteriorly; heavily covered throughout with pulverulence; legs mostly pale yellowish.

Measurements.—Apterous summer vivipara.—Body 2.2 to 2.9 mm.; hind tibiæ 1.2 to 1.5 mm.; first joint of hind tarsi .04 mm. on outer side, .09 mm. on inner side; second joint .22 mm.; antennæ .95 mm.; joint III .32 mm.; IV .14 to .16 mm.; V .16 to .19 mm.; VI .11 + .02 mm.; cornicles .15 mm. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria in alate vivipara 2 to 3 on III, 1 to 2 on IV, 1 on V; in aptera very small, 0 to 1 on III, 1 on IV,

and 1 on V. Unguis conical, stubby. Hairs on hind tibiae pointed, fine, erect, rather numerous, .08 to .10 mm. long, as long or slightly longer than diameter of tibia in aptera; in alatae .10 to .12 mm., barely twice as long as diameter of tibia. Rostrum attaining first segment of abdomen. Mediae twice branched (only 5 alatae studied). Males alate.

Collections.—On *Sabina scopulorum*, on bark of twigs. Recorded in the state in hills near Fort Collins, Laramie-Poudre Tunnel, Masonville, Estes Park, Big Thompson Canon, and Colorado Springs; apterous summer viviparae, Aug. 1 to Sept. 31; alate viviparae, Aug. 1 and 22; oviparae, Sept. 29 to Oct. 17; males, Sept. 29; 8 collections; quite rare.

Types in U. S. Nat. Mus., Cat. No. 42812; paratypes in collection of Colo. Agr. Exp. Sta.

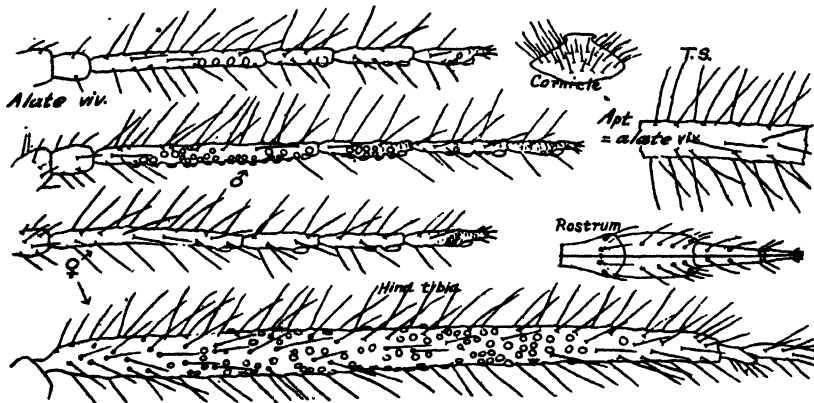


FIG. 37. *Cinara sabinae*.

Cinara sabinae (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 9, 1924. *Lachnus*.

Color.—In all forms.—Light yellowish-brown, marked with dark brown to black on lateral areas, pair of dorsal areas on thorax, solid bands on abdominal segments 5 and 6 and median of 4; heavily pulverulent in cross bands, leaving dark markings exposed; legs almost entirely pale.

Measurements.—Apterous summer vivipara.—Body 3.1 mm.; hind tibiae 1.4 to 1.8 mm.; first joint of hind tarsi .04 mm. on outer side, .09 mm. on inner side, second joint .25 to .28 mm.; antennae 1.1 mm.; joint III .35 to .43 mm.; IV .14 to .18 mm.; V .17 to .20 mm.; VI .14 + .08 to .05 mm.; cornicles .30 mm. in diameter at base. Alate vivipara.—Same as aptera or slightly larger.

Structural Characters.—Secondary sensoria in alate vivipara 3 to 6 on III, 1 to 2 on IV, 2 on V; in aptera, 0 on III, 1 on IV and 2 on V. Unguis slender and finger-like; hairs on hind tibiae, moderately stout, pointed, erect, numerous, .22 mm. long, fully twice as long as diameter of tibia; on body and antennae .16 mm. long. Rostrum surpassing third coxae. Mediae twice branched. Male alate.

Collections.—On *Sabina scopulorum* on bark of twigs, in large colonies; eggs laid on the needles, few on bark. Recorded in the state at Fort Collins, Longmont, Denver, and Big Thompson Canon; fundatrices, April 9 to May 23; apterous summer viviparae, Aug. 10 to Sept. 31; alate viviparae, Aug. 10 to 20; sexuales, Oct. 12 to Nov. 7; 15 collections; common, often in injurious numbers, killing twigs.

Types in U. S. Nat. Mus., Cat. No. 41954; paratypes in collection of Colo. Agr. Exp. Sta.

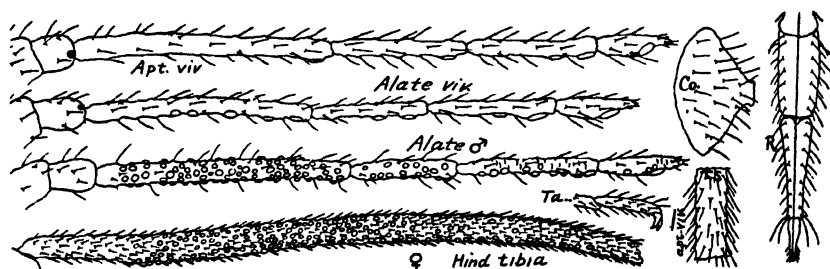


FIG. 38. *Cinara schwarzii*.

***Cinara schwarzii* (Wilson). •**

Wilson, H. F., Can. Ent., Vol. 51, p. 46, 1919. *Lachniella*.

Color.—In all adult forms.—Cinnamon-brown, mottled with black to entirely black; with scattered patches and streaks of pulverulence; legs mostly blackish; cornicles black. Young yellow with head dusky.

Measurements.—Apterous summer vivipara.—Body 3 to 4 mm.; hind tibiae 2.1 to 3 mm.; first joint of hind tarsi .06 mm. on outer side, .12 mm. on inner side; second joint .28 mm.; antennae 1 to 1.6 mm.; joint III .45 to .65 mm.; IV .20 to .32 mm.; V .20 to .33 mm.; VI .10 to .15 + .04 mm.; cornicles .45 to .50 mm. Alate vivipara.—Same as aptera.

Structural Characters.—Hind tibiae sometimes strongly bent. Secondary sensoria rather large, often irregular, somewhat tuberculate, 3 to 7 on III; 1 to 2 on IV; and 1 on V; in apterae 0 to 1 on III, IV and V. Unguis bluntly conical, short. Hairs on hind tibiae pointed, fine, numerous, at angle of 30 degrees or less; in aptera .03 to .05 mm. long, shorter than diameter of tibia; in alata .05 to .07 mm. length about equal to diameter of tibia. Rostrum attaining from middle of abdomen to end of body. Mediae twice branched. Males alate.

Collections.—On *Pinus ponderosa* var. *scopulorum*, on bark of twigs and small branches in colonies; eggs laid on needles. Recorded in the state generally wherever the host occurs on the eastern slope of the Rocky Mountains; fundatrices, April 8 to May 18; apterous summer viviparæ, June 18 to Nov. 8; alate viviparæ, June 18 to Oct. 7; sexuales, Oct. 9 to 27; 35 collections; very common.

Taxonomy.—Near to *C. edulis* Wilson (see *C. edulis* Wilson).

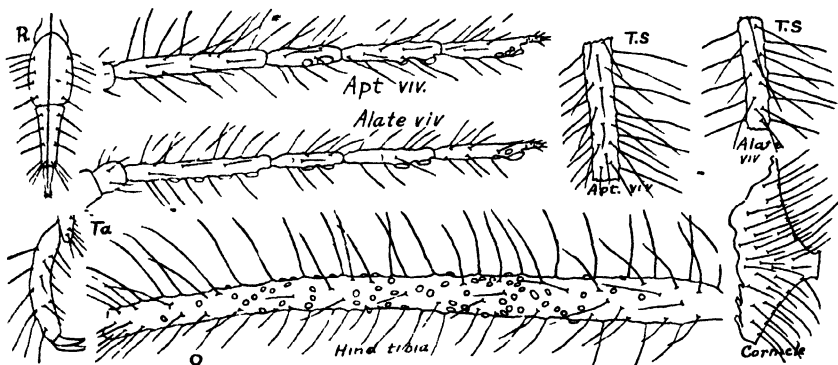


FIG. 39. *Cinara sibiricae*.

***Cinara sibiricae* (Gillette and Palmer).**

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 17, p. 12, 1924. *Lachnus*.

Color.—Pinkish-cinnamon-brown in aptera with two rows of black areas on dorsum; in alatae, entirely dull black; covered with more or less pulverulence; tip of abdomen of oviparæ not heavily powdered; legs entirely dusky; cornicles black.

Measurements.—Apterous summer vivipara.—Body 2.6 to 3 mm. by 1.75 to 2.25 mm.; hind tibiae 1 to 1.2 mm.; first joint of hind tarsi .02 mm. on outer side, .07 mm. on inner side; second joint .29 mm.; antennæ 1 to 1.1 mm.; joint III .26 to .35 mm.; IV .13 to .17 mm.; V .17 to .24 mm.; VI .15 to .20 + .04 to .05 mm.; cornicles .55 mm. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria large and tuberculate; in alate vivipara 4 to 6 on III, 1 to 2 on IV, and 2 to 3 on V; in aptera 0 to 1 on III, 1 to 2 on IV and 2 on V. Unguis arising abruptly, slender, finger-like. Hairs on hind tibiae, pointed, rather fine, at angle of 80 to 90 degrees, .13 to .18 mm. the longest twice as long as diameter of tibia in aptera; in alata .17 to .20 mm. 3 times diameter of tibia. Rostrum attaining third coxæ. Mediæ once branched, (5 alatae taken). Males apterous.

Collections.—On *Juniperus sibirica*, on bark of twigs, solitary; eggs laid on needles. Recorded in the state generally

wherever the host plant occurs; fundatrices, June 2 to July 7; apterous viviparæ, June 13 to Aug. 27; alate viviparæ, June 9, 10 and 13; oviparæ, Oct. 9; males, Sept. 11; 19 collections; rather common, but difficult to find on account of its solitary habits.

Types in U. S. Nat. Mus., Cat. No. 41955; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species seems very close to *C. juniperi* (De Geer) differing only in fewer sensoria in alate vivipara, and the once branched mediæ. However, Swain (Ent. News, Vol. 32, p. 213, 1921) states that specimens of this species in the British Museum show the mediæ once branched in two examples out of five. It appears that the Colorado form may belong to the European species. However, the fact that it occurs in remote regions of the Rocky Mountains and on a native host make it appear improbable that it is introduced.

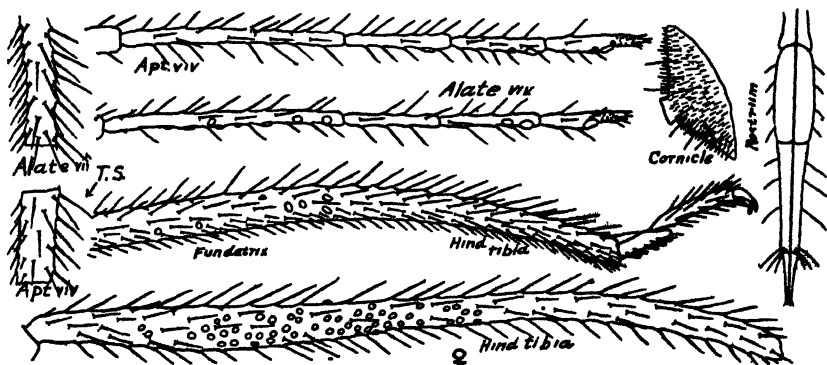


FIG. 40. *Cinara solitaria*.

Cinara solitaria (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 17, 1924. *Lachnus*.

Color.—In all mature forms.—Yellow-brown to dull dusky brown with 6 longitudinal rows of black dots; legs almost entirely dusky; cornicles dusky; young, pale yellow.

Measurements.—Apterous summer vivipara.—Body 2.5 to 3 mm. by 2 mm.; hind tibiae 1.5 mm.; first joint of hind tarsi .06 mm. on outer side, .11 mm. on inner side; second joint .27 mm.; antennæ 1.3 to 1.5 mm., slender; joint III .41 to .55 mm.; IV .18 to .23 mm.; V .20 to .25 mm.; VI .14 + .06 mm.; cornicles with distinct neck, on mamiform base, .45 mm. in diameter at base of cone. Alate viviparæ.—Same as aptera.

Structural Characters.—Secondary sensoria only slightly tuberculate; in alata 6 to 8 on III, 0 to 1 on IV, 0 on V; in aptera 0 to 1 on III, IV and V each. Unguis cylindrical and terminating in a point. Hairs on outside of hind tibiae heavy, spine-like, pointed, rather numerous, at angle of 45 to 90 degrees, .07 to .10 mm. long, about as long as diameter of the tibia in aptera*; in alata .09 to .12 mm., 1.5 to twice as long as diameter of tibiae; on inner side of tibiae finer and shorter and more drooping; hairs on body and antennae spine-like and .02 to .05 mm. long; cornicles with two kinds of hairs, one kind spine-like, .05 to .07 mm. long and sparse, the other kind very fine and numerous, .02 mm. long. Rostrum slender, attaining cornicles. Hind tibiae in fundatrices possessing about 10 scattered sensoria on proximal half. Mediae faint and twice forked. Males not taken. First pair of femora noticeably thickened in apterae.

Collections.—On *Pinus ponderosa* var. *scopulorum*, on bark of tender tips at bases of needles, solitary, spider-like in action. Recorded in the state in foothills near Fort Collins, Bellvue, and Estes Park; fundatrices, April 10 to June 12; apterous summer viviparae, June 20 to Aug. 21; alate viviparae, June 20; oviparae, Oct. 1 and 2; 14 collections; rather common but difficult to find on account of solitary habit and position, head down among the crowded bases of needles.

Types in U. S. Nat. Mus., Cat. No. 41957; paratypes in collection of Colo. Agr. Exp. Sta.

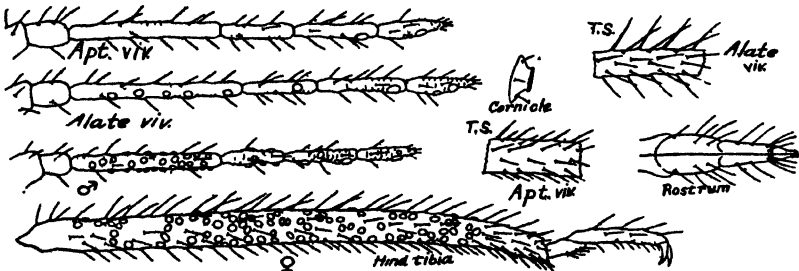


FIG. 41. *Cinara splendens*.

Cinara splendens (Gillette and Palmer).

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 14, 1924. *Lachnus*.

Color.—In mature viviparae.—Rusty brown with colorless area on median of first 3 abdominal segments, and 2 longitudinal rows of green to black areas, especially on thorax; younger individuals greenish to water-white; with slight pulverulence, especially on intersegmental lines

*Statement in original description that hairs are twice as long as diameter of tibiae in apterae is in error.

and lateral areas, heavily covering tip of abdomen of ovipara; legs almost entirely pale; cornicles black.

Measurements.—Apterous summer vivipara.—Body 2.2 to 2.6 mm.; hind tibiae 1.25 to 1.65 mm.; first joint of hind tarsi .05 mm. on outer side, .09 mm. on inner side; second joint .27 mm.; antennae .9 to 1.1 mm.; joint III .26 to .37 mm.; IV .11 to .14 mm.; V .16 to .19 mm.; VI .11 + .03 to .05 mm.; cornicles with base hardly raised, .07 mm. in diameter, sometimes only rims evident. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria in alate viviparae 3 to 7 on III, 0 to 1 on IV; 0 to 1 on V; absent in aptera except 1 on V. Unguis conical, stout. Hairs on outer side of hind tibiae pointed, rather stout, nearly sparse, set at angle of 50 to 70 degrees, .04 to .05 mm., hardly as long as diameter of tibia in aptera; in alata .05 to .08 mm., as long or longer than diameter of tibia. Rostrum stout, attaining third abdominal segment. Mediae twice branched. Males alate.

Collections.—On *Pseudotsuga taxifolia*, on bark of twigs in colonies; eggs laid on needles. Recorded in the state in hills around Estes Park, Bellvue, Pingree Park, Laramie-Poudre Tunnel and Colorado Springs; fundatrices, May 22 and 28; apterous summer viviparae, June 5 to Sept. 5; alate viviparae, June 5 to 20; sexuales, Sept. 8 to Nov. 25; 17 collections; fairly common.

Types in U. S. Nat. Mus., Cat. No. 41956; paratypes in collection of Colo. Agr. Exp. Sta.

Taxonomy.—This species is very close to *C. pseudotsuga* (Wilson) but biological experiments in which several colonies were reared for several generations indicated the constancy of color differences in hind tibiae and body, smaller size and shorter tibial hairs.

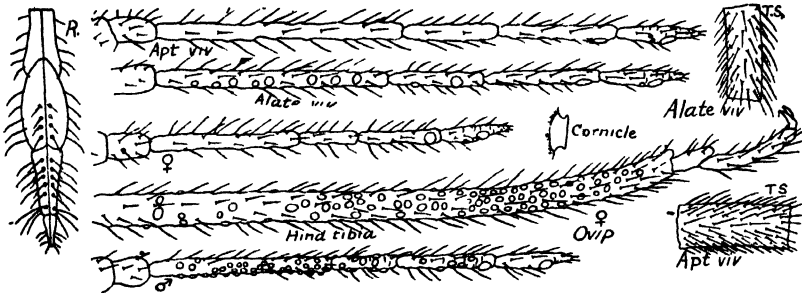
Cinara taxifoliae (Swain).

Swain, Tr. Am. Ent. Soc., Vol. 44, p. 11, 1918. *Lachnus*.

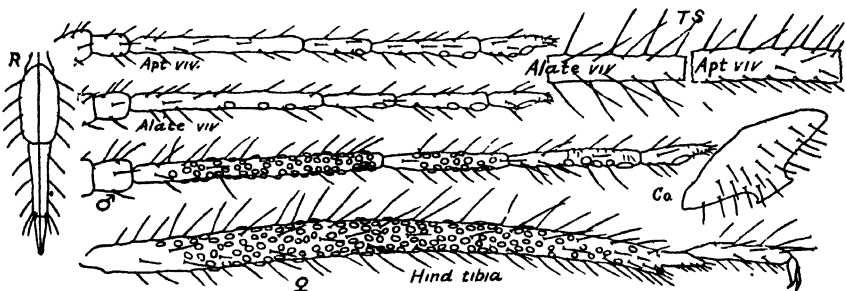
Color.—Mature viviparae.—Yellowish-brown to dark brown or black, with 2 longitudinal rows of black areas also lateral areas black; immature stages pale brownish or sordid white with 2 longitudinal rows of green spots; marked with broken pattern of pulverulence, tip of abdomen of oviparae heavily pulverulent; legs mostly dusky.

Measurements.—Apterous summer vivipara.—Body 3 by 1.5 mm.; hind tibiae 2 to 2.5 mm.; first joint of hind tarsi .05 mm. on outer side, .10 mm. on inner side; second joint .27 mm.; antennae 1.1 to 1.4 mm.; joint III .40 to .50 mm.; IV .15 to .21 mm.; V .22 to .25 mm.; VI .13 + .04 mm.; cornicles without perceptibly raised base, though a small area may be darkened. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria in alate viviparæ 3 to 7 on III, 0 to 2 on IV, 0 to 1 on V; absent in aptera. Unguis conical, short. Hairs on hind tibiæ pointed, fine, numerous, at angle of about 35 degrees, .05 to .07 mm., not as long as diameter of tibia in aptera; .06 to .08 mm. in alata, as long as diameter of tibia; hairs on body and antennæ similar but erect. Rostrum attaining first segment of abdomen. Males alate.

FIG. 42. *Cinara taxifoliae*.

Collections.—On *Pseudotsuga taxifolia* on bark of twigs in colonies; eggs laid on needles. Recorded in the state throughout Larimer County wherever the host plant occurs; fundatrices, May 15 to June 26; apterous summer viviparæ, June 8 to Aug. 21; alate viviparæ, June 20 to July 26; sexuales, Sept. 12 to Oct. 10, oviparæ until Nov. 10; 27 collections; common.

FIG. 43. *Cinara terminalis*.

***Cinara terminalis* (Gillette and Palmer).**

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 17, p. 19, 1924. *Lachnus*.

Color.—In all forms.—Light cinnamon-brown or pinkish-amber, sometimes tinged with green, rather dusky on middle of dorsum from thorax to seventh abdominal segment; with pulverulence on head and

thorax and lateral areas and intersegmental lines on abdomen; cornicles black; legs half or slightly more, dusky, remainder pale yellow.

Measurements.—Apterous summer vivipara.—Body 2.25 mm.; hind tibiae 1.5 to 1.7 mm.; first joint of hind tarsi .06 mm. on outer side, .12 mm. on inner side; second joint .28 mm.; antennae 1 to 1.1 mm.; joint III .35 to .50 mm.; IV .11 to .18 mm.; V .17 to .24 mm.; VI .11 + .03 to .05 mm.; cornicles .30 to .40 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria in alate viviparae 4 on III, 1 on IV, 2 on V; in apterae 0 on III, 1 on IV and 2 on V. Unguis conical, large. Hairs pointed, rather sparse, set at angle of 65 degrees, .05 to .08 mm.; length subequal with diameter of tibia in apterae; in alatae at angle of 70 to 80 degrees, .08 to .10 mm.; 1.5 to 2 times diameter of tibiae. Rostrum nearly as long as body. Mediae twice forked. Males alate.

Collections.—On *Pinus edulis*, on bark of tender twigs, solitary; eggs laid on needles. Recorded in the state near Owl Canon in Larimer County and Walsenburg; fundatrices, June 15; apterous summer viviparae, June 15 to Oct. 5; alate viviparae, June 15 to Oct. 19; oviparae, Oct. 13 to 27; males, Oct. 13; 8 collections; rather common but difficult to find on account of solitary habits.

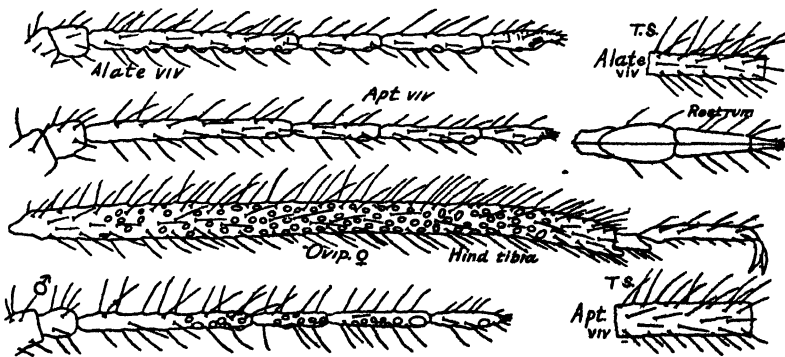


FIG. 44. *Cinara vandykei*.

Cinara vandykei (Wilson).

Wilson, H. F., Can. Ent., Vol. 51, p. 19, 1919. *Lachniella*.

Color.—In all forms.—Dark rufous brown; mottled with yellowish in alatae; pulverulence not evident in apterae, present on intersegmental lines, lateral areas and entire dorsum of seventh abdominal segment; legs mostly black.

Measurements.—Apterous summer vivipara.—Body 2.5 to 3 by 1.5 mm.; hind tibiae 1.7 mm.; first joint .04 mm. on outer side, .09 mm.

on inner side; second joint .30 mm.; antennæ 1.25 mm.; joint III .45 to .55 mm.; IV .16 to .19 mm.; V .20 to .25 mm.; VI .14 to .18 + .03 mm.; cornicles .30 to .50 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria slightly tuberculate, in alate vivipara 6 to 10 on III, 3 to 2 on IV; 1 to 2 on V; in aptera 1 to 2 on III, 0 to 2 on IV and 0 to 1 on V. Unguis conical, short. Hairs on hind tibiæ pointed, fine, fairly numerous, nearly erect to erect, .08 to .10 mm. long, slightly longer than diameter of tibiæ in aptera; in alate vivipara almost twice as long as diameter. Rostrum attaining middle of abdomen. Mediæ twice branched. Males apterous.

Collections.—On *Picea engelmanni*, on bark of twigs; eggs laid on needles. Recorded in the state in Rocky Mountain National Park and Pingree Park; fundatrices, June 11 and July 7; apterous summer viviparæ, July 16 to 28; alate viviparæ, July 16 to 28; oviparæ, July 20 to Aug. 24; males, July 20; 5 collections; rather rare.

Subtribe **Lachnina**.

Characters.—Radial sector arising some distance proximad of apex of stigma, straight or curved; media slender but more distinct than in *Cinarina*. First joint of hind tarsi with outer side shorter than half of inner side. Terminal segment of rostrum inconspicuous. Ocular tubercles evident. Unguis decidedly shorter, usually less than half of base of VI. Color, brown to black, wings often with smoky bands or spots. Living on woody parts of trees and plants.

KEY TO GENERA OF LACHNINA.

- A. Rostrum never much longer than body.
 - B. Stigma not elongated to apex of wing. Unguis not longer than half of base of VI. (Page 875)..... **Lachnus**
 - BB. Stigma elongated to apex of wing. Unguis longer than half of base of VI. (Page 879)..... **Longistigma**
- AA. Rostrum much longer than body. (Page 879)..... **Stomaphis**

Genus **Lachnus** Burmeister.*

Type, *Aphis roboris* Linnaeus. Burmeister, Handbuch der Ent., Vol. 2, pt. 1, p. 91, 1835.

Characters.—Antennæ with rather stout hairs. Rostrum obtuse, never much longer than body. First joint of hind tarsi trapezoidal, outer side at least one-third as long as inner side. Radial sector slightly to strongly curved, arising some distance proximad of apex of stigma; media fine but not faint; wings often smoky. Living on bark of *Quercus* and *Rosa* sp.

Genotype, *Lachnus roboris* (Linnaeus). (See below.)

**Pterochlorus* Rondani (Synonym). See footnote under *Cinara*.

KEY TO SPECIES OF LACHNUS.

- A. Dorsal tubercle absent. Radial sector distinctly curved.
 B. Secondary sensoria present in apterae, large and tuberculate in alate viviparae. (Page 877)..... *rosae*
 BB. Secondary sensoria absent in apterae. (Page 876)..... *montanus*
 AA. Dorsal tubercle present. Radial sector almost straight. (Page 878)..... *salignus*

[Genotype *Lachnus roboris* (Linnaeus).]

Linnaeus, Edition 10, Systema Naturae, p. 452, 1758. *Aphis*.

Color.—In all forms.—Blackish-brown to metallic-black; legs brown; wings smoky.

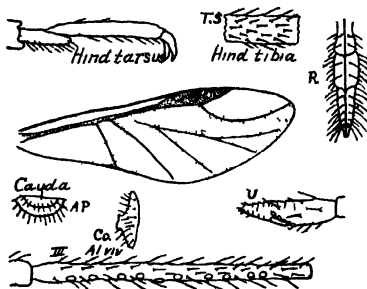


FIG. 45. *Lachnus roboris*.

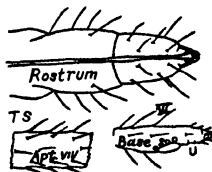


FIG. 46. *Lachnus montanus*.

Measurements.—Alate vivipara.—Body 3.2 to 3.4 mm.; hind tibiae 3.6 mm.; first joint of hind tarsi .06 on outer side, .14 on inner side; second joint .30 mm.; antennae 2 mm.; joint III .73 mm.; IV .32 mm.; V .35 mm.; VI .15 + .06 mm.; cornicles .40 mm. in diameter at base.

Structural Characters.—Secondary sensoria rather flat and small, in irregular row along entire length of joints, on III, 6, (10 to 12 in examples from Cholodkovsky); 3 or 4 on IV, 0 on V, in alate viviparae. Unguis conical and heavy. Hairs pointed, spine-like, on hind tibiae almost sparse, at angle of 30 to 40 degrees, .04 mm. long, hardly half as long as diameter of tibia. Rostrum attaining abdomen; rather stout, terminal segment inconspicuous. Stigmata short and broad; radial sector distinctly curved. Mediae twice forked.

Hosts.—*Quercus*, also recorded on *Pinus sylvestris* and *Picea excelsa*. Not recorded from the state. (Data from Theobald (Aphid. Gr. Brit., Vol. 3, 1929) and from specimens determined and sent by Cholodkovsky.)

***Lachnus montanus* (Wilson).**

Wilson, Can. Ent., Vol. 51, p. 42, 1919. *Lachniella*.

Color.—In all forms.—Rusty or yellowish-brown; legs brown.

Measurements.—Apterous summer vivipara.—Body 3.5 to 3.9 by 2.1 mm.; hind tibiae 2.1 mm.; first joint of hind tarsi .06 mm. on outer

side, .13 mm. on inner side; second joint .23 mm.; antennæ 1.7 mm.; joint III .72 to .80 mm.; IV .31 to .38 mm.; V .40 mm.; VI .17 + .08 mm.; cornicles .70 mm. in diameter at base.

Structural Characters.—Secondary sensoria absent on III, 0 to 2 small ones on IV, 0 to 1 on V. Unguis heavy, parallel-sided with conical tip. Hairs pointed, spine-like, on hind tibiæ at angle of 45 degrees, sparse, .03 to .05 mm. long, about half as long as diameter of tibia; on antennæ and body about the same as on tibiæ. Rostrum surpassing third coxæ, broad and rather obtuse, tip very short and not distinctly separated.

Collections.—On *Quercus* sp. Recorded in the state at Cimmarron; apterous summer viviparæ, Aug. 22; no other forms taken; 1 collection; apparently rare.

Taxonomy.—This species is apparently very close to *A. roboris* L., the only differences noted being shorter tibiæ and larger cornicles in *montanus*.

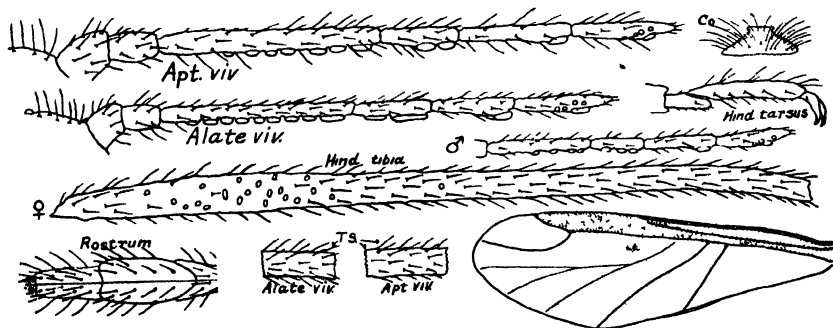


FIG. 47. *Lachnus rosae*.

Lachnus rosae Cholodkovsky.

Cholodkovsky, Zool. Anz. XXII, p. 471, 1899.

Color.—Yellowish or rusty-brown to blackish; legs dusky throughout; wings slightly smoky with darker area between media and stigma.

Measurements.—Apterous summer vivipara.—Body 2.7 to 3.5 mm.; hind tibiæ 1.50 to 2 mm.; first joint of hind tarsi, .05 mm. on outer side, .10 to .11 mm. on inner side, second joint .27 to .32 mm.; antennæ 1.3 to 1.6 mm.; joint III .50 to .63 mm.; IV .18 to .25 mm.; V .20 to .29 mm.; VI .19 to .21 + .04 to .06 mm.; cornicles .20 to .25 mm. in diameter at base. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria as large as diameter of antenna, round, strongly convex, arranged in single row along most of joints; 5 to 10 on III, 1 to 3 on IV, 0 on V in both alatæ and apteræ. Unguis conical and stout. Hairs pointed, fine on hind tibiæ, at angle of 45 degrees, .04 to .05 mm. long, about half as long as diameter of

tibiæ; on antennæ same as on tibiæ; on body and cornicles .07 to .08 mm. long and erect. Rostrum attaining third coxæ, rather broad and obtuse, terminal segment distinct but short. Stigma rather broad but not short; radial sector strongly curved; mediæ twice forked, slightly fainter than other veins. Males apterous.

Collections.—On *Rosa fendleri* and other wild species; in colonies, on bark of stems, near ground. Recorded in the state in foothills near Fort Collins, Bellvue and Log Cabin; apterous summer viviparæ, Aug. 18 to Oct. 25, (alate viviparæ presented by G. F. Knowlton from Logan, Utah, taken June 9); sexuales, Oct. 15 to 25; 7 collections; not common.

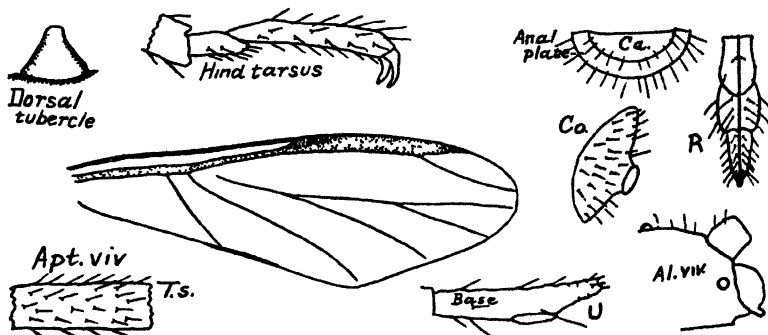


FIG. 48. *Lachnus salignus*.

***Lachnus salignus* (Gmelin).**

Gmelin, *Systema Natura* I., p. 2209, No. 62, 1788. *Aphis*.

Syn. LeBaron, *Second Rept. Nox. and Ben. Ins.* III., p. 138, 1872. *Lachnus dentatus*.

Color.—In all forms.—Blackish with many hairs which cause a gray appearance; legs mostly rufous; wings hyaline.

Measurements.—Apterous summer vivipara.—Body 4.5 to 5.5 mm.; hind tibiæ 3 to 3.5 mm.; first joint of hind tarsi .05 mm. on outer side, .16 mm. on inner side; second joint .40 mm.; antennæ 1.8 to 2 mm.; joint III .70 to .85 mm.; IV .26 to .35 mm.; V .23 to .32 mm.; VI .17 + .06 to .08 mm.; cornicles .40 to .55 mm. in diameter at base of cone. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria circular to oval, often nearly equalling diameter of antenna, strongly convex, about 15 on III, 4 on IV, 0 to 1 on V in alate viviparæ; in apteræ, 1 on III, 1 to 3 on IV, occasionally 1 on V. Unguis conical, heavy. Hairs pointed; on hind tibiæ sparse, at angle of 30 degrees, .05 mm. long, hardly half as long as diameter of tibia in apteræ; .05 to .07 mm. almost or quite as long as diameter of tibiæ in alatæ. Rostrum attaining between second and third coxæ. Stigma long and narrow ending in acute point on margin of wing; radial sector very slightly curved, arising a little distance

proximad of end of stigma; media twice forked; hind wings with 2 cross veins.

Collections.—On *Salix* sp., on bark; in large colonies. Recorded in the state at Fort Collins and Denver, apterous viviparæ, July 10 to Nov. 10; alate viviparæ, Aug. 9 to Nov. 30; sexuales and fundatrices not taken; 25 collections; common.

Taxonomy.—This species was used as type for *Tuberolachnus* Mordvilko on account of the dorsal tubercle. The practically straight radial sector would also seem to separate it from *Lachnus*. Observation of other species in the group indicates that the two characters are not correlated and therefore do not represent a genus complex.

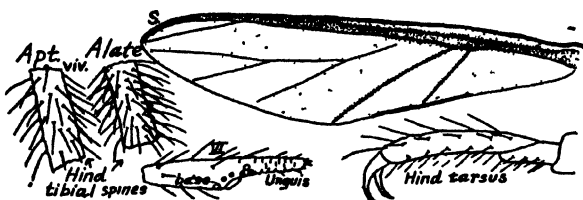


FIG. 49. *Longistigma caryae*.

[Genus *Longistigma* Wilson.]

Type, *Aphis caryae* Harris. Wilson, Can. Ent., Vol. 41, p. 385, 1909.

Characters.—Stigma very long and narrow, ending in an acute point and extending to tip of radial sector; radial sector almost straight, arising some distance proximad of apex of stigma; mediae fine but not faint, twice branched; hind wings with two cross veins. Unguis elongate, finger-like. Antennæ and legs with prominent hairs. Found on woody parts, as trunks and limbs of trees. Not recorded in the state.



FIG. 50. *Stomaphis quercus*.

[Genus *Stomaphis* Walker.]

Type, *Aphis quercus* Linnaeus. Walker, Zoologist, Vol. 28, p. 2000, 1870.

Characters.—Rostrum much longer than body. Unguis hardly more slender than base of VI. Hairs on antennæ very fine and numerous. Tarsi rather stout, first joint nearly triangular. Radial sectors somewhat curved; mediae twice branched. Hind wings with media and cubitus widely separated. Males apterous, with rudimentary mouth parts. Ocular tubercles distinct. Not known from Colorado.

Subtribe **Tramina.**

Characters.—Radial sector arising some distance back of tip of stigma and more or less curved. Rostrum obtuse, terminal joint minute. Second joint of hind tarsi at least half as long as tibia; first joint minute, almost triangular. Living on roots of plants and in nests of ants.

Genus **Trama** Hayden.

Type, *Trama troglodytes* Heyden. Heyden, Mus. Senkb., Vol. 2, p. 293, 1837.

Characters.—Cornicles absent in apteræ, at least. Hairs fine, pointed, numerous. Cauda semilunar; anal plate entire. Hind tarsi at least half as long as tibia. Eyes small, especially in apteræ.

Genotype, *Trama troglodytes* Heyden. (See below.)

KEY TO SPECIES OF TRAMA.

- A. Hind tarsi .5 to .8 of length of tibia. Eyes of few facets only, in apteræ; cornicles present in alatae. (Page 880).....**troglodytes**
 AA. Hind tarsi .9 of tibiae. Eyes of 15 facets or more in apteræ; cornicles not evident in alatae. (Page 881).....**oculata**

[Genotype **Trama troglodytes** (Heyden).]

Heyden, Ent. Beitr. Mus. Senk., Vol. 2, p. 293, 1837.

Color.—In all forms.—Pale yellowish-white to pearly-white or dull brownish-green.

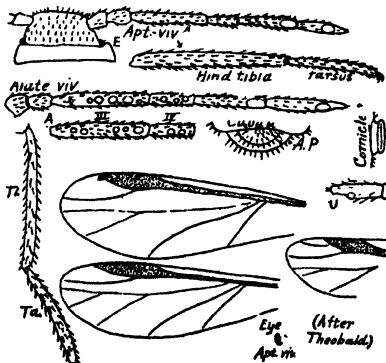


FIG. 51. *Trama troglodytes*.

Measurements.—Apterous summer vivipara.—Body 2.5 to 3.5 mm.; hind tibiae .90 mm.; second joint of hind tarsi .72 mm., more than half as long as hind tibiae; antennæ usually half the length of the body; joint III nearly or quite equal to IV + V; IV less than half III, much shorter than V; V longer than VI; unguis very short and blunt with large sensorium at its base. Alate vivipara.—About the same as aptera.

Structural Characters.—Secondary sensoria of various sizes, 5 to 6 on III, 2 to 3 on IV in alate viviparæ; absent in apteræ. Cornicles absent in apteræ, in alate viviparæ present as hardly more than slightly raised rims. Hairs numerous on body and all appendages. Eyes in apteræ very small and dark, "of a few facets only." Rostrum attaining .50 to .66 of length of body.

Hosts.—On the roots of compositæ and in nests of ants. [Data from Theobald, (Aphid. Gr. Brit., Vol. 3, 1929) and from examples determined and sent by Cholodkovsky.]

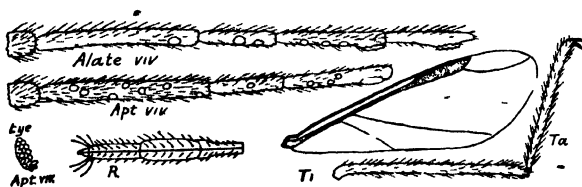


FIG. 52. *Trama oculata*.

Trama oculata* Gillette and Palmer.

Gillette and Palmer, Ann. Ent. Soc. Amer., Vol. 23, p. 547, 1930.

Color.—Pale whitish in young to olive-brown in older examples; legs yellowish.

Measurements.—Apterous vivipara.—Body 3 mm.; hind tibiae 1 mm.; first joint of hind tarsi minute, less than .05 mm. long; second joint .95 mm. long; antennæ 1.50 mm. joint III .45 mm.; IV .19 mm.; V .29 mm.; VI .22 + .06 mm. Alate vivipara.—Same as aptera or slightly smaller.

Structural Characters.—Rostrum broadly lanceolate, attaining middle of abdomen. Unguis conical. Primary sensoria long and flat; secondary sensoria flat, indistinct, and irregularly shaped, scattered about 7 on III, 1 on IV, and 3 on V, in aptera; in alatae 0 to 1 apparent on III, 2 on IV, 2 to 3 on V. Hairs pointed, fine, numerous and drooping, about .03 mm. long, on hind tibiae, as long as half diameter of tibia. Cauda semilunar, broader than long. Eyes normal; in aptera containing more than 15 facets; ocular tubercles consisting of 3 finger-like and diverging facets. Cornicles apparently absent in both apteræ and alatae. Radial sector very slightly curved; media once forked; stigma rather broad.

Collections.—On *Taraxacum officinale*, on roots and in ant's nests. Recorded in the state in foothills near Masonville and in Longmont; apterous viviparæ, Feb. 23 in nature, Jan. 18 in greenhouse; alate viviparæ, Jan. 18; 2 collections; very rare, not recorded in state previous to 1929.

Types in U. S. Nat. Mus., Cat. No. 43001; paratypes in collection of Colo. Agr. Exp. Sta.

*After manuscript was printed a letter was received from A. K. Mordvilko saying *T. oculata* seems identical with *Tr. rara* Mordvilko.

Tribe Callipterini.

Characters.—Wax glands often present. First tarsal joint approximately triangular. Cauda knobbed or semilunar. Anal plate usually bilobed. Antennæ long and slender with few sensoria. Radial sector curved, often faint or absent; media twice forked, never faint. Living free on foliage of plants.

KEY TO SUBTRIBES OF CALLIPTERINI.

- A. Cornicles on low conical base. Wax glands present. (Page 882). *Phyllaphidina*
- AA. Cornicles not on low conical base (unless in *Monellia*).
- B. Radial sector faint or lacking. Wings often banded. (Page 887). *Callipterina*
- BB. Radial sector distinct. Wings never banded.
- C. Ocular tubercles lacking. (Page 905)..... *Saltusaphidina*
- CC. Ocular tubercles present.
- D. Secondary sensoria oval to narrow, transverse. Oviparae with long ovipositor. (Page 911)..... *Drepanosiphina*
- DD. Secondary sensoria circular. Oviparae without long ovipositor.
- E. Hairs not conspicuous on body and antennae. Hind tarsi slender; second joint at least five times as long as first joint. Cornicles not evident. (Not recorded in the state)..... *Monaphidina*
- EE. Hairs conspicuous on body and antennae. Hind tarsi not slender; second joint shorter than five times first joint.
- F. Cornicles present.
- G. Cornicles truncate, sculptured, usually reticulate. (Page 915)..... *Chaltophorina*
- GG. Cornicles cylindrical or vasiform, smooth or faintly reticulated. (Page 927)..... *Pterocommina*
- FF. Cornicles absent. (Page 926)..... *Fullawayina*

Subtribe Phyllaphidina.

Characters.—Cornicles reduced to mere rings on low conical bases. Frontal tubercles not evident. Antennæ 6-jointed, bearing short hairs; unguis of joint VI many times shorter than base. Cauda semilunar or knobbed. Wax glands present. First tarsal joint triangular. Radial sector curved. Media twice branched. Oviparous females producing several eggs, often alate. Living free or in folded leaves, usually protected with flocculent secretion.

KEY TO GENERA OF PHYLLAPHIDINA.

- A. Anal plate deeply cleft and V-shaped. (Page 883)..... *Shivaphis*
- AA. Anal plate not deeply cleft.
- B. Cauda knobbed, anal plate somewhat bilobed. (Page 883)..... *Phyllaphis*
- BB. Cauda not knobbed, anal plate entire.
- C. Antennal joint II shorter than either I or IV in apterae. Fore wing with media arising proximad of stigma.
- D. Oviparous female with annular sensoria on antennae. (Page 883), *Neophyllaphis*
- DD. Oviparous females with small transverse sensoria. (Page 883)..... *Tumalia*
- CC. Antennal joint II longer than I and subequal with IV in apterae. Fore wing with media arising from stigma. (Page 885)..... *Stegophylla*

[Genus *Shivaphis* Das.]

Type, *Shivaphis celti* Das. Das, Mem. Ind. Mus., Vol. 6, p. 246, 1918.

Characters.—Cornicles very short, hardly more than rings. Frontal tubercles not evident. Antennæ 6-jointed. Secondary sensoria elliptical, transverse. Fore wings with mediæ twice branched; hind wings with media and cubitus. Cauda knobbed, elongate. Anal plate deeply divided. Males alate. Oviparæ apterous. Wax glands present. Not recorded in the state.

[Genus *Phyllaphis* Koch.]

Type, *Aphis fagi* Linnaeus. Koch, Die Pflanzenlause Aphiden, p. 248, 1857.

Characters.—Cornicles mere flanges on very low conical bases. Antennæ 6-jointed, minutely setose; sensoria narrowly oval. Fore wings with the mediæ twice branched, hind wings with media and cubitus faintly indicated. Cauda knobbed. Anal plate slightly emarginate. Males usually winged; oviparæ apterous, laying several eggs. Living on foliage, sometimes causing curling of leaves. Not recorded in the state.

[Genus *Neophyllaphis* Takahashi.]

Type, *Neophyllaphis podocarpi* Takahashi. Takahashi, Can. Ent., Vol. 52, p. 19, 1920.

Characters.—Cornicles slightly elevated. Antennæ 6-jointed, with narrow transverse sensoria. Fore wings with radial sector slightly curved, mediæ twice branched. Hind wings with media and cubitus. Cauda not knobbed but large and slightly constricted at base and at middle. Wax glands present. Oviparæ with annular sensoria. Living free on plants. Not recorded in the state.

Genus *Tamalia* Baker.

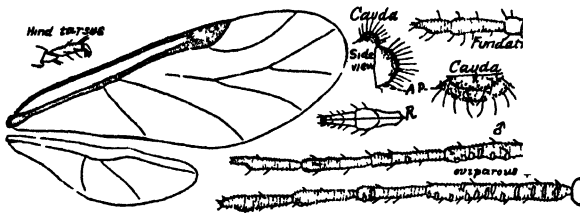
Type, *Pemphigus coweni* Cockerell. Baker, Generic Classification of the Hemipterous Family Aphididae, Bul. 826, p. 24, 1920.

Characters.—Frontal tubercles absent. First tarsal joint triangular. Cornicles mere flanges on low, conical bases. Antennæ 6-jointed, minutely setose and with narrow sensoria. Fore wings with mediæ twice* branched and arising proximad of stigmæ, hind wings with media and cubitus. Cauda broader than long and rounded. Anal plate entire in all female forms. Eyes in apteræ of 3 facets only. Sexes both alate. Oviparæ laying many eggs. Living concealed in pseudo-galls on leaves.

*Baker's statement, in his description of the genus, that the media is once branched is evidently an error or based on an exceptional specimen. No such statement occurs in the descriptions by Cockerell, Cowen, (Gillette and Baker, Colo. Agr. Exp. Sta. Bul. 31, 1895), or Gillette (Can. Ent., Vol. 41, p. 41, 1900), for the Colorado examples, nor by Davidson (Jo. Ec. Ent., Vol. 16, p. 559, 1911), or Essig (Pom. Jo. Ent. Zool., Vol. 7, p. 187, 1915), in their descriptions of the California examples. The numerous alate examples in the collection of the Colo. Agr. Exp. Sta. all have mediæ twice branched.

Genotype *Tamalia coweni* (Cockerell).Cockerell, Can. Ent., Vol. 37, p. 392, 1905. *Pemphigus*.(For fuller description see Gillette, Can. Ent., Vol. 41, p. 41, 1909. *Phyllaphis*).

Color.—Sordid yellow to nearly black with dark bands on all segments in all forms except males, which are light yellow without markings; heavy covering of waxy threads on venter of abdominal segments 5, 6 and 7 in alate oviparæ, absent in viviparæ; wings hyaline; legs dusky to blackish, excepting males.

FIG. 53. *Tamalia coweni*.

Measurements.—Fundatrix. Body 1.25 to 1.50 mm.; stout pyriform; hind tibiæ .22 to .26 mm.; hind tarsi with first joint triangular, second joint .07 mm.; antennæ .30 mm.; joint I .05 mm.; II .04 mm.; III .12 mm.; IV .06 + .03 mm.; cornicles about .09 mm. in diameter at base of flat cone; antennæ and body minutely setulose. Alate oviparæ.—Body 1.5 to 1.7 mm. long; hind tibiæ .41 to .51 mm.; second joint of hind tarsi .09 mm.; antennæ .65 to .85 mm.; joint I .06 mm.; II .05 mm.; III .26 mm.; IV .11 to .13 mm.; V .12 mm.; VI .11 + .02 mm.; cornicles .10 to .12 mm. in diameter at base of cone. Alate viviparæ.—Same as ovipara except that hind tibiæ are .60 mm. long.

Structural Characters.—Media twice forked. Hairs in fundatrix pointed, curved, sparse, about .04 mm. long on body; on legs about .02 mm.; in alatæ blunt, straight and .01 mm. to .02 mm. long. Unguis bluntly conical. Antennæ minutely setulose and annulated. Secondary sensoria transverse elongate, slightly tuberculate about 13 to 15 on III, 4 to 5 on IV, and 0 on V in alatæ, absent in apteræ. Rostrum blunt, barely attaining second coxæ. Males alate.

Collections.—On *Arctostaphylos uva-ursi*, in pod-shaped pseudogalls formed by causing one-third of leaf to fold lengthwise on remaining two-thirds, inclosing the lice and swelling so as to resemble minute pea pods, both green and red, from 10 to 20 mm. long. Recorded in the state in foothills above Bellvue, Fort Collins, in Big Thompson Canon and Estes Park; fundatrices, July 15 to Aug. 8; alate viviparæ, Aug. 5 to Oct.; sexuales, Aug. 5 and 22; 5 collections; very rare.

Genus *Stegophylla* Oestlund.

Type, *Phyllaphis quercicola* Baker. Oestlund, "A Synoptical Key to the Aphididae of Minnesota," 19th Rept. St. Ent. Minn., p. 146, 1922.

Characters.—Frontal tubercles lacking. Unguis much shorter than base of VI. Cornicles mere rings on low conical bases. Antennæ 6-jointed; not noticeably setose, nor with evident hairs; joint II distinctly longer than I and subequal with IV in apterous forms. Secondary sensoria circular. Fore wings with mediæ simple or twice branched* and arising from the stigmæ. Cauda broader than long and rounded, anal plate entire in all female forms. Males usually alate but sometimes apterous. All other forms apterous. Oviparæ laying many eggs. Summer forms covered with flocculent material. Living free on leaves and twigs or in folded leaves of *Quercus*. Only two species known and these seem to be very similar.

Genotype, *Stegophylla quercicola* Baker. (See below.)

KEY TO SPECIES OF STEGOPHYLLA.

- A. Hind wings with two cross veins. (Page 885).....*quercicola*
 AA. Hind wings with one cross vein. (Page 886).....*quercifoliae*

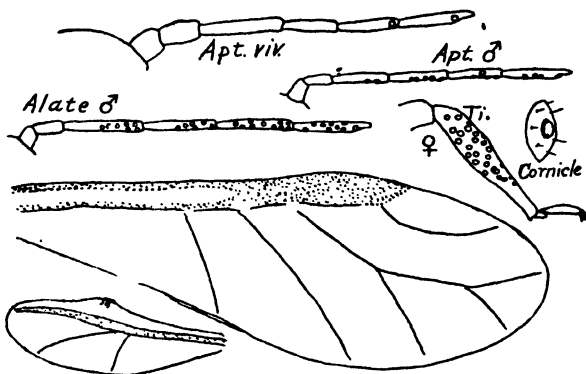


FIG. 54. *Stegophylla quercicola*.

[Genotype *Stegophylla quercicola* (Baker).]

Baker, Ent. News, Vol. 27, p. 362, 1916. *Phyllaphis*.

(For fuller description see Davis, Ent. News, Vol. 22, p. 241.
Phyllaphis querci Fitch.)

Color.—Pale greenish or yellow to brownish with heavy flocculence; legs pale greenish.

*Oestlund, in his original description of the genus, says, "Mediæ of forewings with only one branch," but Davis, (Ent. News, 1911, Vol. 22, p. 241) states and figures venation of media as varying from two branches to simple. Baker applied the name *quercicola* n. n. to the insect described by Davis in above-mentioned reference. Davis' description is accordingly used as basis for the generic description here given.

Measurements.—Apterous vivipara.—Antennæ hardly a third as long as the body, usually 6-jointed, but often 5; usually III and VI subequal, II and IV subequal, V longer than IV but shorter than VI.

Structural Characters.—Abdomen with 6 longitudinal rows of wax glands. Cornicles merely dusky rings. Cauda subobsolete. Secondary sensoria circular; found only in males and hind tibiae of oviparae. Mediae simple or once or twice forked. Rostrum hardly reaching second coxæ. Males both alate and apterous. Oviparae apterous, with basal two-thirds of hind tibiae distinctly swollen and bearing many circular sensoria.

Hosts.—*Quercus agrifolia* and *wizlensis*, free on leaves and twigs or in pseudo-galls on edges of leaves. (Data from Davis, (Ent. News, Vol. 22, p. 241, 1911.) Not recorded in the state.

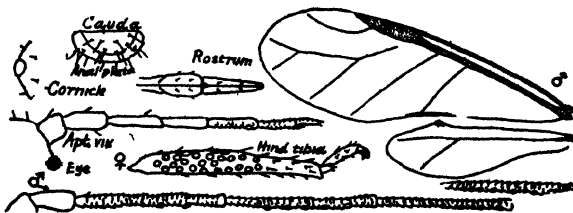


FIG. 55. *Stegophylla quercifoliae*.

Stegophylla quercifoliae (Gillette).

Gillette, Ent. News XXV, p. 272, 1914. *Phyllaphis*.

Color.—Yellow or yellowish-green covered with flocculence; eyes bright red; legs yellow to brown.

Measurements.—Apterous vivipara.—Body 1.1 to 1.5 mm.; hind tibiae .40 mm.; first joint of hind tarsi triangular, second joint .10 mm.; antennæ .50 mm.; joint I .04 mm.; II .07 to .09 mm.; III .09 to .15 mm.; IV .08 to .10 mm.; V .10 to .12 mm.; VI .12 + .02 to .03 mm.

Structural Characters.—Cornicles mere pores on a darkened area, hardly raised. Hairs very sparse, .01 to .02 mm. long. Secondary sensoria present only in male and hind tibiae of oviparae. Unguis finger-like; antennæ imbricated. Rostrum barely attaining second to third coxæ. Males alate. Oviparae with hind tibiae swollen on proximal two-thirds and bearing many large circular sensoria. Mediae quite constantly twice forked. Hind wings with only one cross vein.

Collections.—On *Quercus undulata* and other scrub oaks, free on leaves or in folded leaves. Recorded in southern part of the state on both eastern and western slopes of the Rocky Mountains; apterous viviparae, June 30 to Oct. 7; alate viviparae unknown; sexuales, Oct. 18; 8 collections.

Subtribe **Callipterina.**

Characters.—Antennæ bearing only minute hairs or bristles. Cornicles truncate, never much longer than broad, sometimes mere rims or pores (in *Monellia*). Cauda usually knobbed; anal plate usually indented or bilobed in viviparæ. Apterous forms usually with capitate hairs. Viviparæ, including fundatrices, usually alate. Fore wings with media twice branched; radial sector usually faint. Hind wings with both media and cubitus. Living on leaves or bark, usually solitary.

KEY TO GENERA OF CALLIPTERINA.

- A. Hairs prominent on antennæ and cornicles. (Page 887)..... **Callipterinola**
- AA. Hairs not prominent on antennæ and cornicles.
 - B. Frontal tubercles not distinct.
 - C. Anal plate distinctly divided or bilobed.
 - D. Cornicles truncate, fairly well developed. (Page 888)..... **Myzocallis**
 - DD. Cornicles mere pores. (Page 894)..... **Monellia**
 - CC. Anal plate only slightly indented or entire.
 - D. Imbrications on antennæ minutely setose; unguis at least half as long as base of VI. (Page 895)..... **Symydobius**
 - DD. Imbrications not setose; unguis less than half as long as base of VI. (Page 897)..... **Chromaphis**
 - BB. Frontal tubercles distinct.
 - C. Hairs capitate in alatae. (Page 898)..... **Cepegillettea**
 - CC. Hairs not capitate in alatae.
 - D. Secondary sensoria circular or oval.
 - E. Cornicles not on mammiform base. (Page 899)..... **Calaphis**
 - EE. Cornicles on mammiform base. (Page 902)..... **Oestlundia**
 - DD. Secondary sensoria transverse, more or less narrow. Hairs minute and not capitate on apterae. (Page 904)..... **Euceraphis**

[Genus **Callipterinola** Strand n. n.]

(Strand, Arb. aus Syst. Zool. Inst. Lettlaend Univ. No. 27, p. 47, 1928.)

[(Synonym *Callipterus* Koch.) Type, *Aphis juglandis* Frisch. (Synonym *Aphis juglandis* Goetz, 1778; *Lachnus juglandis* Kaltenbach)].

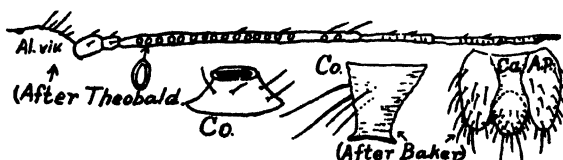


FIG. 56. *Callipterinola juglandis*.

Characters.—Antennæ much longer than body and bearing stout hairs; secondary sensoria oval. Cornicles truncate, bearing long hairs. Cauda knobbed. Anal plate deeply bilobed. Fore wings with radial sector faint, other veins bordered with brown. Living on leaves.

Taxonomy.—*Aphis juglandis* Goetz, chosen by Passerini was the first type set and was included by Koch when he established

the genus. The designation is valid according to rule even though the choice may have been unfortunate as a representative of Koch's idea of the genus. *Callipterus* was pre-occupied by Agassiz in 1846. (See Takahashi, Pr. Ent. Soc. Wash., Vol. 32, No. 1, p. 3, 1930.) Not recorded in the state.

Genus *Myzocallis* Passerini.

Type, *Aphis coryli* Goetze. (Passerini, Gli Afidi, p. 28, 1860).

Characters.—Frontal tubercles indistinct. Antennæ with minute hairs; unguis longer than half base of VI; secondary sensoria usually absent in apteræ. Fore wings usually with radial sector faint. Media twice forked. Hairs capitate on body, conspicuous in apteræ, pointed and inconspicuous in alatae. Cornicles short, truncate, and more or less widened at base. Eyes with ocular tubercles. Cauda knobbed. Anal plate bilobed, to divided. Rostrum moderately obtuse. Living on leaves.

Genotype, *Myzocallis coryli* (Goetz). (See below.)

KEY TO SPECIES OF MYZOCALLIS.

- A. Without spine-like dorsal tubercles.
 - B. Fore wings with dark bands. On *Quercus*.
 - C. Cornicles dark. Unguis twice or more times base of VI; 6–10 sensoria on antennal joint III of alatae. (Page 889) **discolor**
 - CC. Cornicles pale. Unguis hardly twice base of VI; 3–6 sensoria on III. (Page 890). **discolor var. coloradensis**
 - BB. Fore wings hyaline.
 - C. Unguis longer than base of VI.
 - D. Unguis about three times base. Joint III of antennae of alate viviparae with about three sensoria. On *Corylus*. (Page 888) **coryli**
 - DD. Unguis about twice base. Joint III of antennae of alatae with 6–10 sensoria. On *Quercus*. (Page 890) **punctata**
 - CC. Unguis not longer than base of VI.
 - D. Diameter of cornicles at base at least twice that at tip. Body hairs of apterae not noticeably capitate. On *Tilia*. (Page 891) **tiliae**
 - DD. Diameter of cornicles but slightly dilated at base. Body hairs of apterae capitate.
 - E. Cauda elongated. Antennae of apterae with secondary sensoria. On *Ononis* and *Trifolium*. (Page 892) **trifolii**
 - EE. Cauda globular; antennae of apterae without secondary sensoria. On *Robinia*. (Page 891) **robiniae**
 - AA. With spine-like dorsal tubercles. On *Ulmus*. (Page 893) **ulmifolii**

[Genotype *Myzocallis coryli* (Goetz).]

Goetze, Ent. Beitrage, Vol. 2, p. 311, 1778. *Aphis*.

Color.—Pale yellowish-green or white throughout, including nearly entire legs. Wings hyaline.

Measurements.—Alate vivipara.—Body 1 to 1.5 mm. long; hind tibiae .8 to 1 mm.; hind tarsi .10 mm., first joint approximately triangular; antennae 1.3 to 1.7 mm.; joint III .36 to .42 mm.; IV .26 mm.; V .20 to .23 mm.; VI .10 + .23 to .25 mm.; cornicles .04 to .065 mm.; cauda .05 mm. from constriction; .08 mm. from base. Apterous vivipara.—Unknown. Apterous ovipara.—Body 1.5 by .7 mm.; hind tibiae .5 mm.,

proximal two-thirds swollen and bearing many sensoria; antennæ imbricated, .82 mm. long; joint III .20 to .26 mm.; IV .12 to .16 mm.; V .12 to .16 mm.; VI .09 + .20 mm.; cornicles .06 mm.

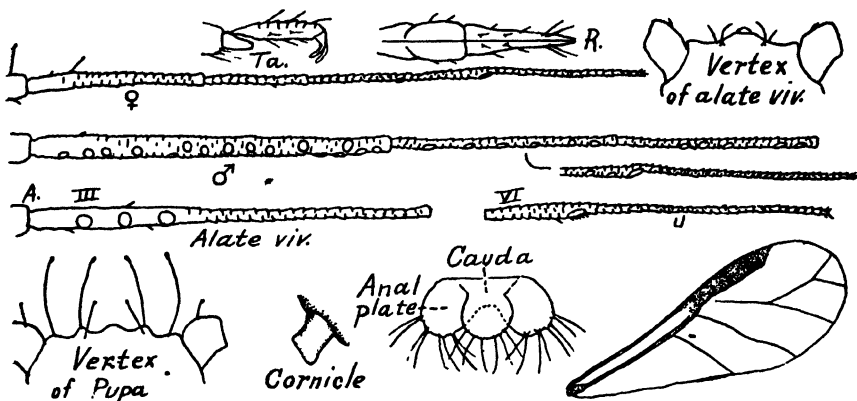


FIG. 57. *Myzocallis coryli*.

Structural Characters.—Secondary sensoria circular and large, 3 or 4 on III in alate viviparæ; absent in apteræ, vertex distinctly produced, especially in alatæ. Frontal tubercles lacking. Rostrum attaining second coxæ. Hairs in apteræ capitate, .07 to .15 mm. long on body; on antennæ minute or absent except proximally; on tibiæ pointed, .03 to .05 mm. long and sparse; on alatæ pointed, sparse, .02 to .03 mm. long, shorter distally on antennæ. Cauda knobbed. Anal plate bilobed except in oviparæ. Radial sector faint. Mediæ twice forked. Males alate.

Host.—*Corylus* sp. on leaves. Not recorded in the state.

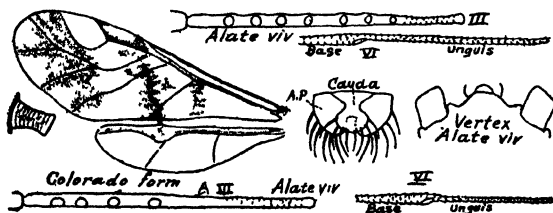


FIG. 58. *Myzocallis discolor*.

[*Myzocallis discolor* (Monell).]

Monell, Bul. U. S. Geol. & Geog. Surv. Terr., V, No. 1, p. 30, 1879. *Callipterus*.

Color.—In all forms.—Greenish or yellowish spotted with dusky; cornicles and area surrounding base dusky; fore wings with conspicuous dusky bands, radial cell clear.

Measurements.—Alate vivipara.—Body 1.5 to 2 mm.; hind tibiae .9 to 1 mm.; antennæ 1.80 mm.; joint III .46 to .55 mm.; IV .30 to .40 mm.; V .24 to .34 mm.; VI .11 to .14 + .20 to .32 mm.; cornicles .06 mm. Rostrum as in type, attaining between first and second coxæ.

Structural Characters.—Radial sector very slightly fainter than other veins. Media twice forked. Vertex of alate vivipara produced. Secondary sensoria round, 6 to 10 in number on joint III of alate viviparæ; absent in apteræ. Unguis two to two and half times base of VI.

Host.—Leaves of *Quercus*. (Not taken in Colorado.)

[Data for above description taken from descriptions by J. Monell in correspondence, and A. C. Baker, (Jo. Ec. Ent., Vol. 10, p. 420, 1917) and amplified from specimens which agree with all characters mentioned in said descriptions.] Typical examples were taken in Michigan, at Lansing and at Detroit, and in Massachusetts at Webster, in June and July; alate viviparæ only.

***Myzocallis discolor* var. *coloradensis* n. var.**

Color.—Same as above except cornicles pale.

Measurements.—Alate vivipara.—Body 1 to 2 mm.; hind tibiae .7 to .9 mm.; antennæ 1.5 to 1.8 mm.; joint III .41 to .60 mm.; IV .30 to .53 mm.; V .28 to .38 mm.; VI .14 to .16 + .20 to .27 mm.; cornicles .05 mm. Apterous summer vivipara, unknown.

Structural Characters.—Secondary sensoria on antennal joint III of alate viviparæ number from 3 to 6 and the unguis is usually once and one half, rarely two times, base of VI. Sexuales similar to *M. coryli* Goetze in sensoria of antennæ. Males alate.

Collections.—On *Quercus alba* and *macrocarpa*, on leaves. Recorded in the state at Fort Collins, Manitou, Salida, and Ouray; alate viviparæ, June 15 to Oct. 23; sexuales, Sept. 27 to Oct. 23; 18 collections; common.

Taxonomy.—This variety shows paler cornicles, fewer sensoria and shorter unguis. These differences do not appear to be sufficient to be considered specific; indeed, Mr. Monell himself, in correspondence with the senior author, pronounced Colorado specimens sent him to be his *discolor*.

***Myzocallis punctata* (Monell).**

Monell, Bul. U. S. Geol. & Geog. Surv. Terr. V, No. 1, p. 30, 1879. *Callipterus*.

Characters.—Similar to *M. discolor* Monell, especially the Colorado form, excepting that the banding of the wings is lacking, only the tips of the veins of fore wings being slightly smoky.

Collections.—On *Quercus alba*, *macrocarpa*, and sp., on leaves. Recorded in the state at Fort Collins and Manitou; alate viviparæ, May 25 to Oct. 20; sexuales, Oct. 18 to 20; 8 collections; fairly common.

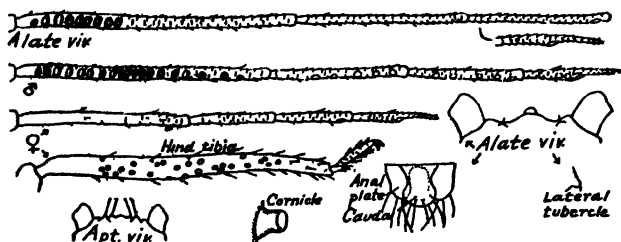


FIG. 59. *Myzocallis robiniae*.

***Myzocallis robiniae* (Gillette).**

Gillette, Can. Ent. XXXIX, p. 395, 1907. *Callipterus*.

Color.—Yellow or greenish-yellow; alatae with a pair of powdery lines extending from antennæ to tip of abdomen; sexuales with dark spots and dashes.

Measurements.—Alate vivipara.—Body 1.6 to 1.9 mm.; hind tibiæ 1 mm.; antennæ 1.6 mm.; joint III .50 to .60 mm.; IV .25 to .40 mm.; V .25 to .34 mm.; VI .13 + .07 to .10 mm. Apterous vivipara.—Unknown.

Structural Characters.—Frontal tubercles inconspicuous. Vertex convex. Secondary sensoria subcircular to oval, 8 to 11 in number on antennal joint III of alate viviparæ; absent in apteræ; forming a single row on joints III, IV, V, and VI of male. Cauda knobbed. Anal plate distinctly bilobed. Cornicles truncate with base slightly enlarged. Wings hyaline. Radial sector faint; media twice forked. Hairs inconspicuous in alatae, except on cauda and anal plate; long and capitate in immature and apterous forms. Males alate.

Collections.—On leaves of *Robinia neomexicana* and *pseudo-acacia*. Recorded in the state in Fort Collins, Boulder, Denver, Trinidad, Sugar City, and Grand Junction; alate viviparæ, June 10 to Oct. 2; and sexuales, Sept. 21 to Nov. 9; 29 collections; common.

Types in U. S. Nat. Mus., Cat. No. 41935; paratypes in collection of Colo. Agr. Exp. Sta.

[*Myzocallis tiliae* (Linnaeus).]

Linnaeus, Edition 10, *Systema Naturae*, p. 452, 1758. *Aphis*.

Color.—In all forms.—Yellow; alatae with black lateral vittæ on head and thorax, continued by broken black bands on abdomen;

antennæ banded. Fore wings with anterior margin and tips of veins smoky, median and anterior portion of stigma paler; legs mostly pale; cornicles slightly dusky; cauda yellow.

Measurements.—Alate vivipara.—Body 2 mm. long; hind tibiae .9 mm.; hind tarsi .15 mm.; antennæ 2 to 2.19 mm.; joint III .64 to .74 mm.; IV .41 to .49 mm.; V .37 to .45 mm.; VI .26 to .32 + .195 to .245 mm.; cornicles .057 mm.; cauda .145 mm. entire length, .09 mm. from neck. Apterous viviparae.—Unknown.

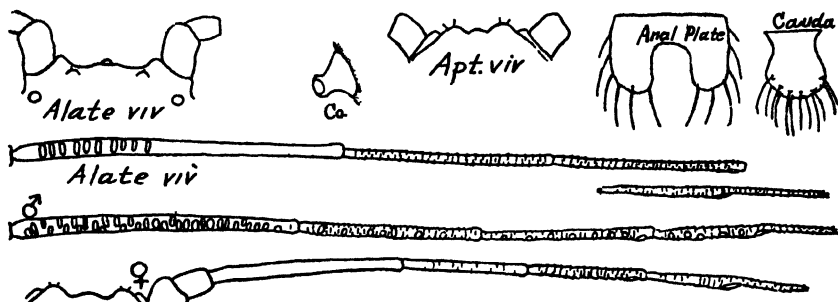


FIG. 60. *Myzocallis tiliae*.

Structural Characters.—Frontal tubercles slightly developed. Vertex with a pair of tubercles close to anterior margin, each with one or two hairs. Antennæ distinctly annulated. Secondary sensoria oval, transverse, 10 to 17 in number on antennal joint III of alate viviparae; absent on apterae. Cornicles truncate with base enlarged to twice diameter of tip. Cauda knob-like with slight neck. Anal plate decidedly bifid. Male alate with oval sensoria on all joints of antennæ, including VI. Hairs in both alatae and apterae pointed, inconspicuous, .01 to .02 mm. long on antennæ and body, longer on cauda and anal plate.

Host.—Leaves of *Tilia*. Not recorded from the state.

[Data from Davis, (Ann. Ent. Soc. Amer., p. 33, 1909) amplified from specimens determined by A. A. Granovsky collected in the eastern states.]

Taxonomy.—This species differs from the type in the absence of secondary sensoria on the antennæ and inconspicuous hairs on body of apterae, slight antennal tubercles and dilated cornicle bases. It has been placed in several different genera by different authorities.

[*Myzocallis trifolii* (Monell).]

Monell, Can. Ent. XIV, p. 14, 1882. *Callipterus*.

Color.—In viviparae.—Greenish-yellow with dusky tubercles on dorsum; legs mostly pale; wings hyaline with veins narrowly bordered and tipped with brownish.

Measurements.—Alate vivipara.—Body 1.4 to 1.6 mm. long; hind tibiae .8 mm.; hind tarsi .13 mm.; antennæ 1.66 mm.; joint III .49 to .54 mm.; IV .36 to .39 mm.; V .30 to .35 mm.; VI .15 to .18 + .15 to .18 mm.; cornicles .066 mm.; cauda .14 mm. entire length, .09 mm. from neck. Apterous summer vivipara.—Same as alata.

Structural Characters.—Secondary sensoria oval to elongate, transverse, with rather broad margins, 10 to 12 in a single row on proximal half of III in both alate and apterous viviparæ as well as oviparæ. Antennæ imbricated. Cauda elongate, knobbed but with tip upturned. Anal plate decidedly bifid, except in oviparæ where it is entire. Rostrum not attaining second coxæ. Frontal tubercles slightly developed. Vertex slightly produced. Hairs inconspicuous in alata; .07 mm. long and capitate in apteræ. Males alate.



FIG. 61. *Myzocallis trifolii*.

Host.—*Trifolium pratense* on undersides of leaves. Not recorded in the state.

Taxonomy.—Theobald, (Aphid Gr. Brit., Vol. 2, 1927) considers this species as a synonym of *ononidis* Kalténbach. The genus *Therioaphis* has been erected for this form but the writers do not consider these characters to represent a true generic complex.

***Myzocallis ulmifolii* (Monell).**

Monell, Bul. U. S. Geol. & Geog. Surv. Terr., V, No. 1, p. 29, 1879. *Callipterus*.

Color.—In all forms.—Pale yellow to greenish, alate viviparæ with dusky vitta on head and pronotum and speckles on abdomen; legs pale; wings hyaline.

Measurements.—Alate vivipara.—Body 1.5 to 1.7 mm.; hind tibiae .70 to .80 mm.; hind tarsi .11 mm.; antennæ 1.45 to 1.55 mm.; joint III .50 to .52 mm.; IV .30 to .33 mm.; V .27 to .30 mm.; VI .12 to .15 + .13 mm.; cornicles .02 mm. long. Cauda .05 mm. from neck, .09 mm. entire length. Apterous summer vivipara.—Unknown.

Structural Characters.—Vertex produced. Frontal tubercles but slightly developed. Secondary sensoria transverse, elongate, 6 to 10 on basal half of joint III of alate viviparæ; absent in apteræ. Hairs in alata minute; in apteræ, capitate and .08 to .10 mm. long on body; minute on antennæ. Cauda knobbed. Anal plate bilobed. Cornicles obliquely truncated. Rostrum obtuse, hardly attaining second coxæ.

Radial sector faint. Media twice forked. Alate viviparæ with two pairs of finger-like dorsal tubercles on first and second abdominal segments and smaller ones on succeeding segments. Oviparæ with hind tibiæ considerably swollen along almost entire length and bearing numerous sensoria. Males alate.

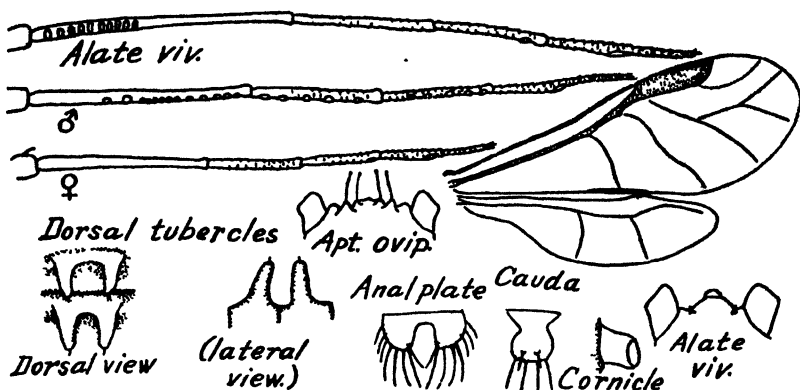


FIG. 62. *Myzocallis ulmifolii*.

Collections.—On leaves of *Ulmus americana*. Recorded in the state at Fort Collins, Boulder, Denver and La Junta; alate viviparæ, July 28 to Oct. 7; sexuales, Sept. 3 to Oct. 23; 21 collections; abundant at times.

Taxonomy.—This species resembles very closely *Myzocallis pulchellus* Glendenning (1929, Can. Ent., Vol. 61, p. 237) but differs in the longer unguis and fewer sensoria. *M. pulchellus* has unguis hardly as long as half of base and 18 to 25 sensoria on antennal joint III of alate viviparæ.

Genus *Monellia* Oestlund.

Type, *Aphis caryella* Fitch. (Oestlund, Geol. & Nat. Hist. Survey, Minn., Bul. No. 4, p. 44, 1887.)

Characters.—Frontal tubercles lacking. Antennæ without prominent hairs; unguis not longer than base of VI; secondary sensoria elongate-oval. Cornicles mere pores. Cauda knobbed. Anal plate distinctly bilobed. Hairs on body inconspicuous in alatæ; long and capitate in apteræ and nymphs. Differs from *Myzocallis* only in character of cornicles. Living on leaves of trees.

Type species not described here on account of uncertainty as to exact identity.

***Monellia caryae* (Monell).**

Monell, Bul. U. S. Geol. & Geog. Surv. Terr. V, No. 1, p. 31, 1879. *Callipterus*.

Color.—Viviparæ.—Pale yellow without markings; legs pale, antennæ banded, wings hyaline; stigma pale yellow; males with dusky bands on abdomen; oviparæ speckled.

Measurements.—Alate vivipara.—Body 1.3 to 1.5 mm.; hind tibiæ .80 mm.; hind tarsi .10 mm.; antennæ 1 to 1.2 mm.; joint III .32 to .41 mm.; IV .23 to .27 mm.; V .18 to .24 mm.; VI .13 to .16 + .12 to .15 mm.; cauda .10 mm. entire length; .05 mm. from neck. Apterous viviparæ not found.

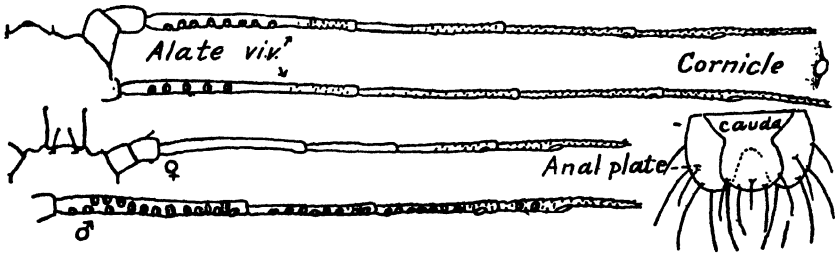


FIG. 63. *Monellia caryae*.

Structural Characters.—Vertex slightly produced. Frontal tubercles not developed. Cornicles mere pores. Cauda knobbed, with slight neck. Anal plate bilobed. Hairs pointed and inconspicuous in alata; capitate and .09 mm. long on body of apteræ and nymphs. Rostrum obtuse, attaining about to second coxæ. Secondary sensoria oval to transverse, absent on antennæ of apterous oviparæ; 6 to 10 in a row in alate viviparæ on basal half to two-thirds of joint III, which portion is not noticeably thickened. Mediæ twice forked; radial sector faint. Males alate.

Collections.—On leaves of *Carya* and *Juglans* sp. Recorded in Colorado on leaves of *Juglans regia*, near Fort Collins, Boulder, and Denver; alate viviparæ, June 10 to Sept. 4; sexuales, Sept. 24 to Oct. 18; twelve collections; rather common where host occurs.

Genus *Symydobius* Mordvilko.

Type, *Aphis oblonga* Heyden. (Mordvilko, Varshava Universitetskiia Izvestiia, Vol. 8, No. 58, p. 65, 1894).

Characters.—Frontal tubercles slightly developed. Antennæ with inconspicuous hairs; unguis not longer than base of VI. Secondary and primary sensoria, oval to circular; present in apteræ. Hairs on body somewhat spine-like. Imbrications on antennæ and cornicles minutely setose. Cornicles truncate, somewhat broader at base and with flange. Cauda semi-circular, broader than long. Anal plate entire or slightly indented. Living on bark of twigs of trees.

[Genotype *Symydobius oblongus* (Heyden).]

Heyden, Ent. Beitr. Musc. Senk., Vol. 2, p. 298, 1837. *Aphis*.

Color.—In all forms.—Brown; veins of fore wings heavily shadowed, not smoky at tips. Antennæ annulated.

Measurements.—Alate vivipara.—Antennal joint III 1.12 mm.; IV .72 mm.; V .528 mm.; VI .208 + .112 mm. Apterous vivipara.—Body 3.25 to 3.50 mm.; antennal joint III 1.16 mm.; IV .72 mm.; V .51 mm.; VI .144 + .112 mm.

Structural Characters.—Secondary sensoria covering only basal half of antennal joint III; present in male on joints III and V. Cauda semi-circular. Anal plate entire. Imbrications on antennæ and cornicles minutely setose. Males apterous.

Host.—Bark of older twigs of *Betula alba*. (Data from Baker Can. Ent., Vol. 50, p. 318, 1918 amplified from specimens received from P. Van der Goot.) Not recorded from the state.

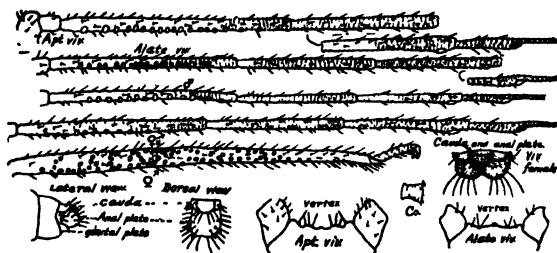


FIG. 64. *Symydobius intermedius*.

Symydobius intermedius Gillette and Palmer.

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 23, p. 543, 1930.

Color.—In all forms.—Tawny-olive to greenish with dusky cross bands on abdomen, often coalescing; cornicles pale; antennæ annulated; legs dusky to black; fore wings with veins heavily bordered, the media and cubitus being the most broadly bordered.

Measurements.—Alate vivipara.—Body 2 mm.; hind tibiae 1.4 mm.; antennæ 2.4 mm.; joint III .64 to .88 mm.; IV .47 to .60 mm.; V .44 to .52 mm.; VI .16 to .27 + .10 to .14 mm.; cornicles .07 mm.; cauda .05 mm. Apterous summer vivipara.—Same as alata to slightly larger.

Structural Characters.—Rostrum obtuse, attaining second coxæ. Vertex but slightly convex. Frontal tubercles slightly developed in apteræ, hardly noticeable in alatæ. Secondary sensoria circular to oval, arranged in single row, extending along entire length of antennal joint III, 12 to 22 in number in all forms; sensoriation in males same as in females. Cauda, semilunar to wart-like. Anal plate indented and bearing two lobe-like swellings at base, one on either side of cauda.

Hairs on cauda, numerous, bushy; on antennæ spine-like but inconspicuous; on body moderately conspicuous, .03 to .04 mm. long. Males apterous.

Collections.—On bark of twigs of *Betula fontinalis* and *Betula* sp. Recorded in Colorado at Fort Collins, Boulder, Estes Park, Stove Prairie (near Bellvue) and Crawford; fundatrices, April 7; apterous summer viviparæ, June 2 to Oct. 7, alate viviparæ, June 2 to Aug. 9, apterous oviparæ, Sept. 25 to Oct. 13, apterous males, Oct. 15; twenty collections; fairly common.

Taxonomy.—This species is distinguished from *S. oblongus* (Heyden) by the indented anal plate, the distribution of secondary sensoria along entire joint, and the absence of sensoria on antennal joint V in male. From *S. americanus* Baker it is separated by the shorter unguis, equal to base of VI in *americanus*.

Types in the U. S. Nat. Mus., Cat. No. 42819; paratypes in collection of Colo. Agr. Exp. Sta.

[Genus **Chromaphis** Walker.]*

Type, *Lachnus juglandicola* Kaltenbach. (Walker, The Zoologist, Vol. 5, p. 2001, 1870).

Characters.—Frontal tubercles inconspicuous. Antennæ shorter than body; unguis much shorter than base of VI. Cornicles truncate. Cauda globular. Anal plate emarginate. Hairs on antennæ minute; on body of oviparæ and young, moderately long and capitate. Living on leaves and twigs of trees.

[Genotype **Chromaphis juglandicola** (Kalt.).]

Kaltenbach, Mon. der Pflanzenlause, p. 151, 1843. *Lachnus*.

Color.—In all forms.—Pale lemon-yellow to salmon-pink to brownish; legs pale with dusky spot distally on femur; stigma pale, cornicles and cauda pale. Wings hyaline.

Measurements.—Alate vivipara.—Body 1.6 to 2.5 mm.; hind tibiæ .65 to .70 mm.; hind tarsi .10 mm.; antennæ .77 to 1 mm.; joint III .26 to .40 mm.; IV .15 to .23 mm.; V .13 to .19 mm.; VI .08 + .03 to .04 mm.; cornicles .04 to .05 mm., about as wide as long; cauda .056 mm. Apterous vivipara.—Unknown.

Structural Characters.—Vertex convex. Frontal tubercles, undeveloped. Hairs pointed and short in alatæ, long and capitate in apteræ.

*Borner (Arch. Klass. Phylog. Ent., Bd. I, Heft. 2, p. 162, 1930) considers *Chromaphis* to replace *Callipterus* and holds the erection of *Callipterinola* as unnecessary.

Secondary sensoria on antennæ oval, transverse, 6 to 8 scattered in single row along entire length of joint III in alate viviparæ, absent in apteræ. Cornicles truncate, tapering, with occasional hairs. Radial sector faint, especially at base; media twice forked. Rostrum obtuse, attaining between first and second coxæ. Fundatrices and males alate, oviparæ apterous.

Host.—Leaves of *Juglans* sp. Not recorded from the state, but likely to occur.

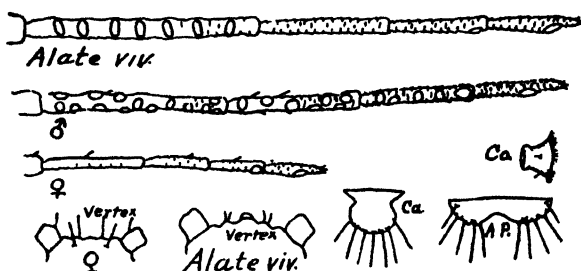


FIG. 65. *Chromaphis juglandicola*.

Genus *Cepigillettea* Granovsky.

Type, *Cepigillettea betulaeifoliae* Granovsky. (Granovsky, Proc. Ent. Soc. Wash., Vol. 30, p. 113, 1928).

Characters.—Frontal tubercles prominent; joint I of antennæ macrosiphum-like. Vertex and antennæ with short capitate hairs; alike in alatae and apteræ. Antennal joint III with secondary sensoria in all forms; permanent sensorium at base of unguis long, oval, without noticeable cilia. Antennæ longer than body; unguis longer than base of VI. Cornicles short, truncate, imbricated. Cauda spatulate, long, with evident neck and long basal portion; tip Calaphis-like. Anal plate moderately cleft. Fore wings, with veins heavy and somewhat bordered, at least smoky at tip. Radial sector present or absent. Living on leaves of trees.

Genotype *Cepigillettea betulaeifoliae* Granovsky.

Granovsky, A. A., Proc. Ent. Soc. of Wash., Vol. 30, p. 115, 1928.

Color.—In all forms.—Yellowish-green; with head and thorax of alatae yellow-brown; antennæ annulated with black; legs pale; stigmæ yellow.

Measurements.—Alate vivipara.—Body 2.5 mm. to base of cauda; antennæ 5.22 mm.; joint III 1.50 mm.; IV 1.30 mm.; V 1.04 mm.; VI .32 + .60 mm.; cornicles .16 mm.; cauda .38 mm. entire length, .19 mm. from neck. Apterous vivipara.—About the same as alata.

Structural Characters.—Antennæ minutely imbricated. Secondary sensoria oval on antennal joint III, from 13 to 20 in alatae, and 10 to 15 in apterae. Rostrum attaining second coxae. Mediae twice forked. Males alate. Other characters as in description for genus.

Collections.—On leaves of *Betula*. Recorded from Fort Collins, Colorado; alate and apterous viviparae; one collection; Aug. 18; rare.

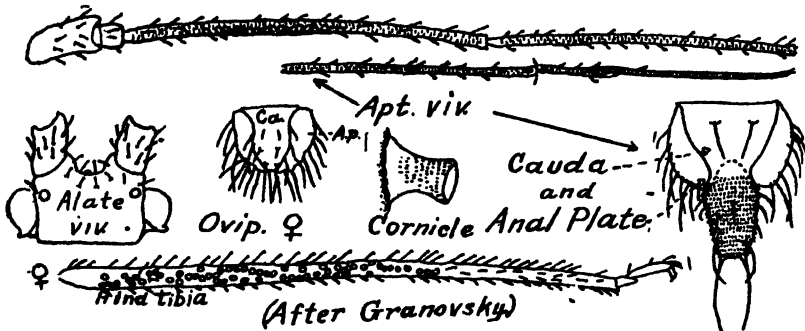


FIG. 66. *Cepegillettea betulae foliae*.

Genus *Calaphis* Walsh.

Type, *Calaphis betulella* Walsh. (Walsh, Proc. Ent. Soc. Phila., Vol. 1, p. 301, 1863).

Characters.—Frontal tubercles well developed. Vertex not produced. Hairs on vertex and body, capitate and long in apterae, and nymphs, short and blunt in alatae. Antennæ longer than the body, with minute spine-like hairs; unguis much longer than base; secondary sensoria sub-circular to circular. Wing veins somewhat smoky; radial sector faint or absent. Cornicles short, somewhat broader at base. Cauda knobbed. Anal plate bilobed in viviparae. Both cauda and anal plate with numerous stout hairs. Antennæ of apterae, both viviparae and oviparae, with secondary sensoria. Permanent sensorium at base of unguis long-oval and with cilia. Living on leaves of trees, more or less solitary.

Genotype, *Calaphis betulella* Walsh. (See below.)

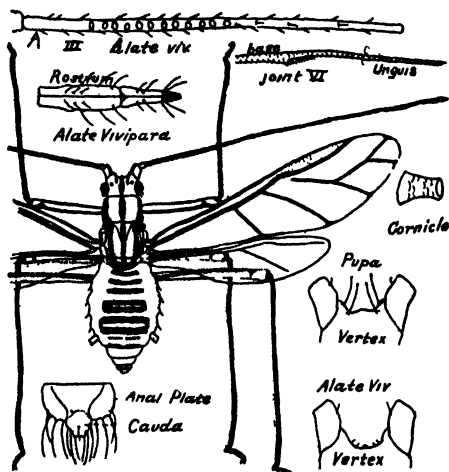
KEY TO SPECIES OF CALAPHIS.

- A. Without dusky markings in viviparae. (Page 901).....*betulaecolens*
- AA. With distinct dusky markings.
- B. With conspicuous vittae in alatae. Hairs capitate and long in apterae, pointed and minute in alatae. (Page 900).....*betulella*
- BB. Without vittae but with dusky bands on all segments in both alate and apterae. Hairs pointed and conspicuous in both alatae and apterae. (Page 901).....*annulata*

[Genotype *Calaphis betulella* Walsh.]

Walsh, Proc. Ent. Soc. Phil., I, p. 301, 1863.

Color.—Yellowish in alate viviparæ, with three black vittæ over head and thorax, and black bands bordering anterior and posterior margins of abdominal segments, 2 to 6 in alate vivipara; nymphs and apteræ speckled with dusky; femora pale with black vittæ and fasciæ; tibiæ and tarsi black; stigmæ and veins narrowly margined with black, and smoky at tips.

FIG. 67. *Calaphis betulella*.

Measurements.—Alate vivipara.—Body 2 to 2.5 mm.; hind tibiæ 2 to 2.25 mm.; hind tarsi .15 mm.; antennæ 3.6 to 4 mm.; joint III 1.25 to 1.35 mm.; IV .85 to .90 mm.; V .60 to .70 mm.; VI, .25 to .30 + .45 to .53 mm.; cornicles, .10 mm.; cauda .15 mm. entire length, .06 mm. from neck. Apterous vivipara.—Same as alata.

Structural Characters.—Secondary sensoria oval, transverse, in single row on proximal two-thirds of joint III, 10 to 17 in number, absent on other joints. Vertex concave. Frontal tubercles strongly developed, diverging. Cornicles obliquely truncate, faintly imbricated, slightly broader at base. Anal plate bilobed in viviparæ. Hairs pointed, .03 to .05 mm. long on body and legs in alata; in nymphs and apteræ, capitate, .10 to .12 mm. long on body. Radial sector obsolete. Media twice forked.

Host.—Leaves of *Betula* sp. Not yet recorded from the state, but likely to occur.

***Calaphis betulaecolens* (Fitch).**

Fitch, Rept. Reg. Univ. State N. Y. Cab. Nat. Hist., p. 66, 1851. *Aphis*.

Color.—In all forms.—Whitish to yellowish tinged with green or red; without black markings, except in sexuales; legs pale with customary dusky markings. Fore wings with veins narrowly bordered and tipped with dusky; radial sector usually obsolete at base, sometimes invisible throughout.

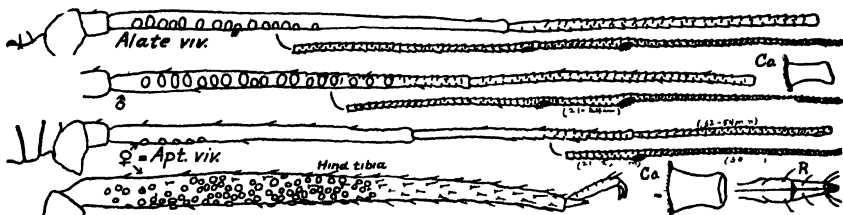


FIG. 68. *Calaphis betulaecolens*.

Measurements.—Alate vivipara.—Body 2 to 2.5 mm.; hind tibiae 2 to 2.40 mm.; hind tarsi .13 to .15 mm.; antennae 4.50 mm.; joint III 1 to 1.40 mm.; IV .83 to .93 mm.; V .70 to .75 mm.; VI .28 to .33 + .70 to .75 mm.; cornicles .11 mm. Apterous summer vivipara.—Same as alate vivipara or slightly smaller.

Structural Characters.—Vertex not produced. Frontal tubercles moderately developed. Secondary sensoria oval, transverse, 8 to 14 on proximal two-thirds of III in alate viviparae; 4 to 6 on III in apterae. Cauda and anal plate as in *betulella*. Rostrum attaining between second and third coxae. Hairs pointed and .02 to .03 mm. on body; .05 mm. on hind tibiae in alatae; capitate and .10 to .12 mm. on body of apterae. Radial sector usually evident at least distally. Mediae twice forked. Fundatrices apterous.

Collections.—On *Betula fontinalis* and *alba* and *Alnus tenuifolia*, on leaves. Recorded from the state at Fort Collins, Boulder, Denver and Manitou; fundatrices, May 26 and 31; apterous summer viviparae, June 14 to July 26; alate viviparae, June 19 to Oct. 16; sexuales, Oct. 10 to 25; 23 collections; rather common.

***Calaphis annulata* (Koch).**

Koch, Die Pflanzenlaus Aphiden, p. 7, 1854. *Chaitophorus*.

Color.—Greenish-yellow marked with brown on head and thorax and with dusky bands on abdominal segments in both alatae and apterae; legs dusky; wings hyaline with veins slightly bordered and tipped with dusky; stigma pale medially.

Measurements.—Alate vivipara.—Body 2 mm.; hind tibiae .75 to .9 mm.; hind tarsi .12 mm.; antennæ 1.3 mm.; joint III .37 to .53 mm.; IV .19 to .31 mm.; V .17 to .23 mm.; VI .10 + .21 to .24 mm.; cornicles .06 to .07 mm.; cauda .09 mm. entire length, .06 mm. from neck. Apterous summer vivipara.—Same as alata.

Structural Characters.—Vertex produced. Frontal tubercles developed, equal with vertex. Secondary sensoria circular, in single row on proximal two-thirds of joint III, 4 to 8 in alate viviparæ; 2 to 5 in apteræ. Hairs pointed, curved, .10 to .15 mm. long on body; .05 mm. on hind tibiae and .02 mm. on antennæ of apteræ; on alatæ usually slightly shorter. Cornicles truncate, with setose imbrications. Cauda wart-like. Anal plate indented. Rostrum obtuse, attaining second coxæ. Radial sector faint, especially proximally. Tubercles on lateral margins of all abdominal segments, a pair on occiput and on vertex in both alate and apterous viviparæ.

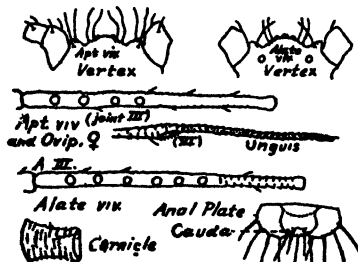


FIG. 69. *Calaphis annulata*.

Collections.—On *Betula alba*, on leaves. Recorded from the state at Fort Collins, Denver, Greeley and Boulder; apterous and alate summer viviparæ, July 8 to Sept. 26; oviparæ, Sept. 16; 6 collections; rather rare.

Genus *Oestlundia* Granovsky.

Type, *Euceraflis flava* Davidson. (Granovsky, Proc. Ent. Soc. Wash., Vol. 32, p. 61, 1930).

Characters.—Frontal tubercles distinct. Antennæ longer than the body. Secondary sensoria subcircular, present on joint III of both alatæ and apteræ. Cornicles truncate with enlarged distal end and with distinctly mammiform base. Cauda rather elongated, with slight neck. Anal plate with shallow U-shaped cleft. Hairs inconspicuous on antennæ and body, blunt or slightly capitate. Body somewhat woolly. Radial sector evident. Media twice forked. Living on leaves and twigs of trees.

Genotype *Oestlundella flava* (Davidson).

Davidson, Jo. Ec. Ent., Vol. 5, p. 406, 1912. *Eucraphis*.

Color.—In all forms.—Pale yellow; with cornicles and a pair of dorso-lateral vittæ on thorax of alate viviparæ and two pairs of longitudinal rows of spots on dorsum of oviparæ dark brown; antennæ annulated; cornicles black; wings hyaline; stigma pale. Alate viviparæ, more or less woolly; oviparæ with tufts of threads on venter of abdominal segments 5 and 6.

Measurements.—Alate vivipara.—Body 3.3 mm.; hind tibiae 3 to 3.2 mm.; hind tarsi .20 mm.; antennæ 4 mm.; joint III 1.05 to 1.26 mm.; IV .73 to .88 mm.; V .60 to .70 mm.; VI .30 to .35 + .25 to .27 mm.; cornicles .10 mm. long, .16 mm. in diameter at base; cauda .15 mm. entire length, .10 mm. from neck.

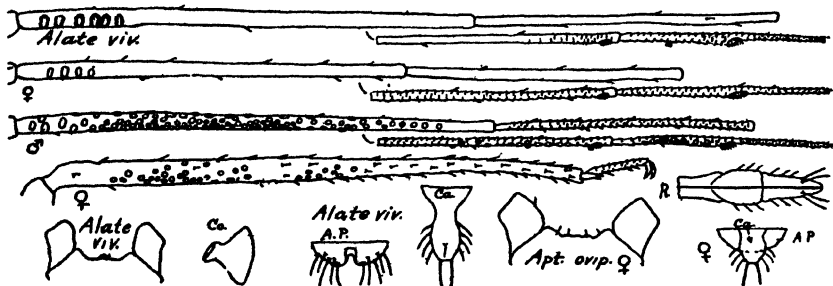


FIG. 70. *Oestlundiella flava*.

Structural Characters.—Frontal tubercles well developed. Vertex concave. Secondary sensoria on antennæ, oval, transverse, present on joint III in both alate viviparæ and apterous oviparæ, 2 to 7, rarely 10 in number. Hairs on both antennæ and body, in all forms, inconspicuous, very slightly capitate in apteræ. Cornicles obliquely truncate distally, with enlarged tip and distinctly mammiform base, diameter at base more than twice that at tip. Cauda rather spatulate with slight neck. Anal plate with shallow U-shaped cleft. Rostrum obtuse, attaining between first and second coxæ. Oviparæ with tibiæ slightly swollen. Males alate.

Collections.—On leaves of *Alnus rhombifolia* and sp. Recorded from northern part of the state on the eastern slope of the Rockies; alate viviparæ, June 7 to Oct. 13; sexuales, Oct. 11 and 13; 7 collections; rather rare.

Genus **Euceraphis** Walker.

Type, *Callipterus betulae* Koch. (Walker, The Zoologist, p. 2001, 1870).

Characters.—Frontal tubercles well developed. Antennæ longer than the body; unguis not longer than base of VI; secondary sensoria on antennal joint III, narrow, transverse, located near base, present in alate only; permanent sensorium on VI long, oval, and fringed. Cornicles truncate. Cauda somewhat knobbed. Anal plate entire or slightly emarginate. Wax glands often present in alatæ. Hairs not capitate; minute on body of alatæ and on antennæ of all forms. Radial sector distinct. Oviparæ producing many eggs. Living on leaves and twigs of trees, usually solitary.

Genotype, *Euceraphis betulae* (Koch). (See below.)

KEY TO SPECIES OF EUCERAPHIS.

- A. Joint III of antennæ of alate viviparæ with sensoria crowded. Unguis subequal with base of VI. On *Betula*. (Page 904) ***betulae***
 AA. Joint III of antennæ of alate viviparæ with sensoria not crowded. Unguis shorter than base of VI. On *Alnus* and *Betula*. (Page 904) ***gillettei***

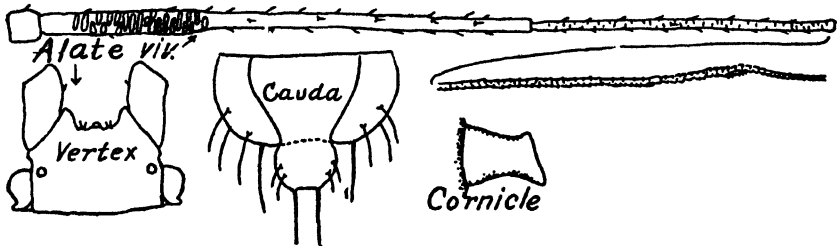


FIG. 71. *Euceraphis betulae*.

[Genotype ***Euceraphis betulae*** (Koch).]

Koch, Die Pflanzenlausen Aphiden, p. 217, 1855. *Callipterus*.

Descriptions of this species by different writers vary somewhat, especially as to color markings. Van der Goot considers several varieties. As the authors do not have access to any authoritative specimens and the species does not seem to occur in Colorado, a detailed specific description will not be attempted here.

Euceraphis gillettei Davidson.

Davidson, Jour. Econ. Ent., VIII, p. 421, 1915.

Color.—Thorax pale brownish, abdomen pale apple green to yellowish without marking in alate viviparæ; dark dashes on abdomen in sexuales, oviparæ brownish. Alate viviparæ usually with flocculence.

Measurements.—Alate summer vivipara.—Body 2.5 to 3.5 mm.; hind tibiae 2.9 mm.; antennae 5.2 mm.; joint III 1.9 mm.; IV 1.25 mm.; V 1 to 1.1 mm.; VI .37 to .40 + .24 to .30 mm.; cornicles .11 mm.; cauda .13 mm. entire length, .10 mm. from neck. Apterous viviparae, unknown.

Structural Characters.—Vertex concave. Frontal tubercles well developed. Secondary sensoria narrow, transverse, about 13 to 16 in single row on swollen proximal .3 to .5 of joint III in alate viviparae; absent in apterae. Alate viviparae with two pairs of wart-like to finger-like dorsal tubercles. Other characters as in description for genus. Fundatrices and males alate. Oviparae apterous.

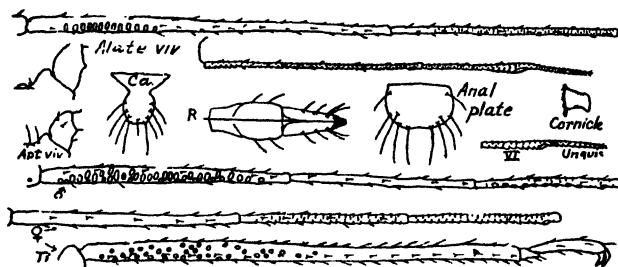


FIG. 72. *Euceraphis gillettei*.

Collections.—On leaves and tender twigs of *Alnus tenuifolia* and *Betula fontinalis*. Recorded in the state throughout the eastern slope of the Rocky Mountains and at Cedaredge on the western slope; alate viviparae, May 29 to Aug. 22; sexuales, Sept. 29, to Oct. 20; twenty-nine collections; common.

Taxonomy.—This species may be a variety of *E. betulae* (Koch) as that species appears to be quite variable and authorities appear to differ as to characters. *E. gillettei* is distinguished by fewer antennal sensoria and a shorter unguis, always shorter than base of VI. In *E. betulae* the unguis is subequal with base of VI.

Subtribe **Saltusaphidina.**

Characters.—Ocular tubercles lacking. Body narrow. Cauda knobbed. Anal plate bilobed. Imbrications on antennae setose. Fore wings with radial sector curved. Hind wings with cubitus obsolete. Rostrum obtuse, very broad, terminal joint obsolete.

KEY TO GENERA OF SALTUSAPHIDINA.

- A. Body hairs flabellate.
- B. Terminal tergite bifid, bearing cylindrical hairs. (Page 906)... **Saltusaphis**
- BB. Terminal tergite not bifid, bearing flabellate hairs. (Page 907)... **Iziphya**
- AA. Body hairs pointed. (Page 909)..... **Thripsaphis**

[Genus *Saltusaphis* Theobald.]

Type, *Saltusaphis scirpus* Theobald. (Theobald, Bul. Ent. Research, Vol. 6, pt. 2, p. 138, 1915).

Characters.—Head long and broad. Body narrow, hardly wider than thorax. Antennæ 6-jointed. Legs short; first and second femora thickened. Frontal tubercles and ocular tubercles lacking. Eighth tergite bilobed. Cauda knobbed. Anal plate bilobed. Hairs on body, flabellate; on eighth tergite cylindrical. Cornicles truncate on flat base. Mediæ twice forked. Hind wings without cubitus. Imbrications setose on antennæ, cornicles and cauda. Living on leaves of *Cyperaceæ*.

[Genotype *Saltusaphis scirpus* Theobald.]

Theobald, Bul. Ent. Research, VI, p. 138, 1915.

Color.—In all forms.—Yellowish; with dusky vittæ on head and speckles on abdomen in apteræ; dashes in alate; legs mostly yellowish; wing veins bordered and tipped with smoky; cornicles dusky.

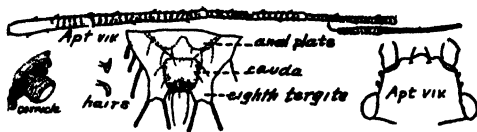


FIG. 73. *Saltusaphis scirpus*.

Measurements.—Apterous vivipara.—Body 2 to 2.5 mm.; abdomen hardly broader than thorax; hind tibiæ .65 mm.; hind tarsi .15 mm.; antennæ, 2 mm.; joint III .65 mm.; IV .31 to .35 mm.; V .26 to .29 mm.; VI .14 + .25 to .30 mm.; cornicles .03 to .04 mm.

Structural Characters.—Rostrum obtuse, attaining between first and second coxæ. Antennæ with minute hairs and setose imbrications. Secondary sensoria circular, 15 to 17 in single row on proximal .6 of joint III in alate viviparæ; absent in apteræ. Vertex very slightly convex. Frontal tubercles lacking. Cornicles truncate, on dusky area, surface setulose. Eighth tergite of abdomen bifid, projecting over cauda.* Cauda knobbed. Anal plate bilobed. Hairs flabellate on body, except on vertex, eighth tergite, cauda, and anal plate. Mediæ twice forked. Hind wing with cubital vein obsolete.

Host.—Leaves of *Scirpus* sp. With jumping habits. (Data from description by Theobald and from paratypes sent by him.) Not recorded from the state.

*Theobald mistook eighth tergite for cauda.

Genus *Iziphyha* Nevsky.

Type, *Iziphyha maculata* Nevsky. (Nevsky, V. P., Uzbekistan Exp. Sta. Plant Protection, No. 16, p. 314, 1929.) (Syn. *Caricaphis* Börner. Arch. Klassif. Phylog. Ent., Bd. I, Heft. 2, p. 165, 1930.)

Characters.—Head and thorax elongated. Eyes without ocular tubercles. Hairs on body and head flabellate, arising from large tubercles. Cornicles truncate, on broad hairy cones. Cauda cordiform. Anal plate divided. Antennæ 6-jointed, with spine-like hairs. Eighth tergite not bilobed, but tuberculate.

Genotype, *Iziphyha maculata* Nevsky. (See below.)

KEY TO SPECIES OF IZIPHHA.

- A. Cornicles set on raised cones. (Page 907).....*maculata*
 AA. Cornicles not set on raised cones. (Page 908).....*flabella*

[Genotype *Iziphyha maculata* Nevsky.]

Nevsky, V. P., Uzbekistan Exp. Sta. Plant Protection, No. 16, p. 314, 1929.

Color.—In apterous vivipara.—Greenish-yellow, with dusky specks and blotches on dorsum, tending to form two vittæ, transverse band between cornicles and covering eighth tergite.

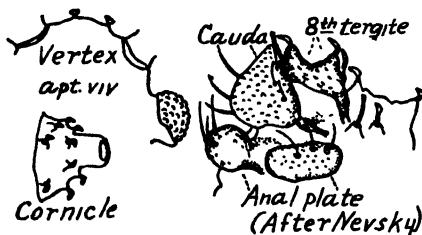


FIG. 74. *Iziphyha maculata*.

Measurements.—Apterous vivipara.—Body 1.3 to 1.7 mm.; antennæ 1.4 mm.; joint III .40 mm.; IV .21 mm.; V .24 mm.; VI .14 + .26 mm.; cornicles cylindrical portion, .06 mm. long, .05 mm. wide; conical portion, .05 mm. long and .16 mm. in diameter at base; cauda .10 mm.; hairs .03 mm. long.

Structural Characters.—Head long. Vertex slightly convex. Hairs on body throughout, flabellate, set on large tubercles; on antennæ setigerous, on legs cylindrical or setigerous. Cornicles without flanges, truncate on raised conical base, which bears flabellate hairs. Cauda cordiform, pointed distally, bearing two or three pointed, curved hairs on each side. Anal plate divided. Eighth tergite somewhat covering cauda and bearing flabellate hairs on large tubercles.

Host.—*Cynodon dactylon*, on leaves. (Data from Nevsky 1929.) Not recorded in the state.

Iziphya flabella (Sanborn).

Sanborn, Kansas Aphididae, p. 37, 1904. *Chaitophorus*.

(Same as *Callipterus flabellus* Sanborn by Gillette, 1909, Ent. News, Vol. 20, p. 120).

Color.—In all forms.—Pale yellowish-green, with dusky specks and blotches tending to form vittæ and dorsal patches in alate and apterous viviparæ; femora dark; tibiæ pale; cornicles dusky; cauda pale; wing veins heavy, somewhat bordered and tipped with smoky.

Measurements.—Apterous summer vivipara.—Body 1.5 to 2 mm.; hind tibiæ .47 to .54 mm.; hind tarsi .14 mm.; antennæ 1.4 to 1.6 mm.; III .31 to .50 mm.; IV .17 to .26 mm.; V .20 to .24 mm.; VI .12 to .16 + .18 to .25 mm.; cornicles .04 mm.; cauda .12 mm. entire length, .07 mm. from neck. Alate vivipara.—Same as aptera.

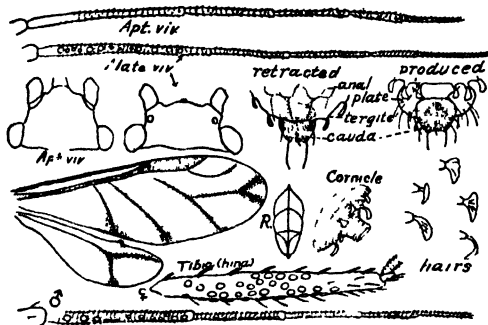


FIG. 75. *Iziphya flabella*.

Structural Characters.—Vertex strongly convex in apteræ, slightly convex in alatæ. Antennæ with imbrications setulose, without evident hairs. Secondary sensoria round, minute, 15 on basal three-quarters of joint III in alate viviparæ; present on all joints in males; absent in apteræ. Rostrum obtuse, barely surpassing first coxæ. Ocular tubercles lacking. Cornicles cylindrical, truncate on a circular base which bears flabellate hairs, entire surface setulose. Terminal tergite rounded, entire, hardly projecting over cauda. Cauda knobbed, distal end truncate or bluntly rounded. Anal plate bilobed. Hairs flabellate on small tubercles on body, excepting on vertex, cauda, anal plate, and inner side of tibiæ. Mediæ twice forked. Hind wings with cubital vein absent. Males apterous.

Collections.—On leaves of *Carex* sp. (small species on low meadows). With jumping habits. Recorded in the state at Fort Collins; fundatrices, April 28 and May 1; apterous summer viviparæ, May 2 to Sept. 28; alate viviparæ, April 28 to June 11, also Sept. 4; apterous oviparæ, Oct. 27; apterous males, Oct. 7 to 29; 31 collections; common.

Genus *Thripsaphis* Gillette.

Type, *Brachycolus ballii* Gillette. (Gillette, Can. Ent., Vol. 49, p. 193, 1917).

Characters.—Body very long, flat and slender. Ocular tubercles not evident. Antennæ much shorter than body, 6-jointed and with secondary sensoria round; permanent sensoria with cilia. Rostrum very broad and short. Cornicles mere rings on segment VI. Cauda knobbed. Anal plate divided in all forms. Body with spine-like hairs. Fore wings with mediæ usually twice branched, frequently deformed; hind wings with cubitus faint or absent. Living on leaves and stems of *Gramineæ* and *Cyperaceæ*.

Genotype, *Thripsaphis ballii* (Gillette). (See below.)

KEY TO SPECIES OF THRIPSAPHIS.

- A. Vertex of apterae not with wart-like projection.
 - B. Vertex of apterae moderately convex. Antennae of apterae without secondary sensoria. (Page 909).....*ballii*
 - BB. Vertex of apterae strongly convex. Antennae of apterae with secondary sensoria. (Page 910).....*producta*
- AA. Vertex of apterae with wart-like projection. (Page 911).....*verrucosa*

Genotype *Thripsaphis ballii* (Gillette).

Gillette, Can. Ent. XL, p. 67, 1908. *Brachycolus*.

Color.—Pale greenish, with dusky on head and thorax and cross bands and speckles on abdomen in all forms; slightly pulverulent; legs slightly dusky; oviparae with tufts of secretion on venter of tip of abdomen.

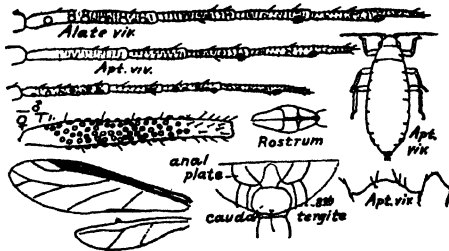


FIG. 76. *Thripsaphis ballii*.

Measurements.—Apterous vivipara.—Body 2 to 2.5 mm. by .75 to .80 mm., dorso-ventrally compressed, thrips-like; hind tibiae .40 to .70 mm.; antennæ .80 mm.; joint III .19 to .26 mm.; IV .13 mm.; V .14 mm.; VI .14 + .09 mm.; cauda .09 mm. entire length, .04 to .05 mm. from neck. Alate vivipara.—Body 1.7 by .5 mm.; hind tibiae .55 mm.; antennæ 1.05 mm.; joint III .31 to .40 mm.; IV .17 to .25 mm.; V .18 to .21 mm.; VI .14 to .16 + .09 to .12 mm.

Structural Characters.—Vertex rounded. Frontal tubercles not developed. Antennæ, imbricated. Body surface very minutely setose.

Secondary sensoria circular, large, in single row along entire length of joint III in alate viviparæ; absent in apteræ; present in male on antennal joints III, IV, V, and VI. Hairs spine-like, minute, about .10 mm. to .20 mm. long on antennæ and body. Cornicles mere pores on sixth abdominal segments. Rostrum very broad, barely surpassing first coxæ. Anal plate bilobed in all forms. Terminal abdominal tergite broadly rounded and projecting posteriorly, usually covering cauda. Males apterous.

Collections.—On leaves and stems of *Carex nebraskensis*. Recorded from Colorado at Fort Collins and Rocky Ford; fundatrices, April 27; apterous summer viviparæ, April 29 to Sept. 17; alate viviparæ, May 27 to July 13; oviparæ, Oct. 30 to Nov. 9; males, Oct. 14 to 17; 31 collections; common.

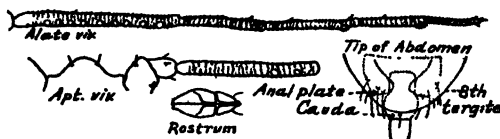


FIG. 77. *Thripsaphis producta*.

Thripsaphis producta Gillette.

Gillette, C. P., Can. Ent., Vol. 49, p. 196, 1917.

Color.—Blackish in viviparæ due to heavy banding and mottling; legs and antennæ black.

Measurements.—Apterous summer vivipara.—Body 2 by .7 mm.; hind tibiae, .45 to .50 mm.; antennæ .95 mm.; joint III .26 to .30 mm.; IV .15 to .18 mm.; V .15 mm.; VI .13 + .08 mm.; cauda .06 mm. entire length, .04 mm. from neck. Alate vivipara.—About the same or with appendages slightly longer.

Structural Characters.—Vertex strongly convex, especially in apteræ. Frontal tubercles undeveloped. Secondary sensoria round, arranged in a single row on antennal joint III 9 to 11 in alate viviparæ; 1 to 3 in apterous viviparæ. Antennal imbrications minutely setose. Last dorsal tergite broadly rounded and extending more or less over cauda. Cornicles mere rings. Mediæ usually twice branched. Hind wings with cubital vein rather faint. Anal plate bilobed with rather broad U-shaped cleft. Cauda knobbed. Rostrum very broad, barely surpassing first coxæ.

Collections.—On leaves of *Carex nebraskensis*. Recorded in the state at Fort Collins; fundatrices (?), May 5 to 20; apterous summer viviparæ, June 20 to Aug. 17; alate viviparæ, June 3 to 20; 8 collections; common.

Taxonomy.—This species differs from *T. ballii* Gillette in the darker color, especially in the apteræ, presence of secondary

sensoria on antennæ of apteræ, greater number of sensoria on joint III of alatæ, more produced vertex in apteræ, and usually more U-shaped cleft in anal plate.

***Thripsaphis verrucosa* Gillette.**

Gillette, Can. Ent., Vol. 49, p. 194, 1917.

Color.—Apteræ.—Pale greenish-yellow with slight dusky transverse dashes, appendages blackish; oviparæ with deep yellow spot just anterior to cornicles and same size as cornicle pores, and with wax threads projecting laterally from abdominal segments 6 and 7.

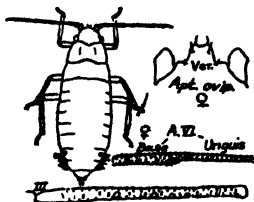


FIG. 78. *Thripsaphis verrucosa*.

Measurements.—Fundatrix.—Body 2 to 2.5 by .5 mm.; hind tibiae .50 mm.; hind tarsi .14 mm.; antennæ .90 to 1.05 mm.; joint III .32 to .37 mm.; IV .14 to .17 mm.; V .14 to .17 mm.; VI .12 to .13 + .10 to .11 mm.; cauda .07 mm., .035 mm. from neck. Ovipara.—Body 2 to 3 by .96 mm.; hind tibiae .75 to .80 mm.; hind tarsi .15 mm.; antennæ 1.60 to 1.80 mm.; joint III .55 to .60 mm.; IV .30 to .35 mm.; V .28 to .33 mm.; VI .15 to .18 + .20 mm.; cauda .15 mm.; from neck, .08 mm.

Structural Characters.—Vertex with wart-like projection .05 to .07 mm. long, as long as first antennal joint. Frontal tubercles absent. Secondary sensoria circular, in single row on distal half of joint III, 2 to 4 in number. Cornicles mere pores on middle of lateral portions of segment 6. Cauda knobbed. Anal plate divided. Antennæ with imbrications faintly setulose. Hind tibiae in oviparæ slightly swollen and bearing numerous small, slightly convex sensoria. Hairs throughout very short and inconspicuous.

Collections.—On leaves of *Carex nebraskensis*. Taken in the state at Fort Collins; fundatrices, May 15; oviparæ, Oct. 15 to Dec. 2; 3 collections; rare.

Subtribe Drepanosiphina.

Characters.—Frontal tubercles developed. Antennæ much longer than body. Abdomen of oviparous females with segments posterior to cornicles elongated to form long ovipositor. Cauda knobbed. Anal plate indented. Cornicles much longer than broad. Mediæ twice forked.

Structural Characters.—Vertex slightly convex. Frontal tubercles distinctly developed. Cornicles with flanges, tapering, in one view

strongly swollen basally on posterior side, usually carried at right angles to body. Secondary sensoria large, oval, transverse, with cilia, arranged in a single row, 8 to 12 in number on basal .6 of joint III of alate viviparæ; absent in apteræ; numerous on all joints of male. Dorsum of alatae with a pair of long finger-like tubercles on abdominal segments I and III, largest on III and slightly united at base, a pair of shorter ones on II and IV each. Hairs very inconspicuous in alatae; rather long, .10 to .15 mm. in apteræ and slightly capitate; on antennæ, minute, about .01 mm. long. Fore wings with veins bordered with smoky, stigma dusky, with pale center. Rostrum obtuse, hardly attaining second coxæ. Fundatrices and males alate.

Collections.—On leaves of *Acer saccharinum*, solitary. Recorded from the state at Greeley, Boulder, Denver, and Fort Collins; fundatrices, May 12 to June 1; alate viviparæ, May 26 to Oct. 2; apterous viviparæ, unknown; apterous oviparæ, Sept. 30 to Nov. 7; males, Sept. 30 to Oct. 2; 50 collections; common.

Genus *Drepanosiphum* Koch.

Type, *Aphis platanoides* Schrank. (Koch, Die Pflanzenlause Aphiden, p. 201, 1855).

Characters.—Frontal tubercles distinct. Antennæ longer than the body, with minute hairs; unguis many times longer than base of VI. Secondary sensoria, large, oval and ciliated. Cornicles more than five times as long as wide, slightly swollen, smooth. Cauda knobbed. Anal plate indented in viviparæ. Oviparæ with terminal abdominal segments elongated to form ovipositor.

Genotype, *Drepanosiphum platanoides* (Schrank). (See below.)

KEY TO SPECIES OF DREPANOSIPHUM.

- A. Cornicles swollen slightly in distal half. Oviparæ without secondary sensoria. (Page 913)..... **platanoides**
- AA. Cornicles not swollen in distal half. Oviparæ with secondary sensoria. (Page 914)..... **braggii**

[Genotype *Drepanosiphum platanoides* (Schrank).]

Schrank, Fauna Boica, II, p. 112, 1801. *Aphis*.

Color.—Various shades of yellow or reddish to green with black markings and bands; legs and cornicles yellow to dusky orange. Wings hyaline.

Measurements.—Alate summer vivipara.—Body 2.7 to 3.5 mm.; hind tibiæ 2 to 2.25 mm.; hind tarsi .20 mm.; antennæ 5 mm.; joint III 1.3 to 1.6 mm.; IV .90 to 1.2 mm.; V .78 to .84 mm.; VI .14 + .80 to .96 mm.; cornicles .65 mm.

Structural Characters.—Vertex convex. Frontal tubercles distinctly developed. Secondary sensoria large, oval to narrow transverse, arranged in a single row, about 20 in number on proximal half of joint III in alate viviparæ; numerous on joints III, IV, and V, in male; absent

in oviparæ. Rostrum obtuse, hardly attaining second coxæ. Cornicles slightly swollen with narrow flange. Cauda elongate globular, knobbed. Anal plate indented in viviparæ. Hairs fine and pointed in alatæ; heavier, .12 mm. long, and slightly capitate in apteræ. Males alate. Oviparæ with tip of abdomen forming elongated ovipositor.

Hosts.—Leaves of *Acer platanoides*, *campestris* and *pseudo-platanus*. Not reported from the state.

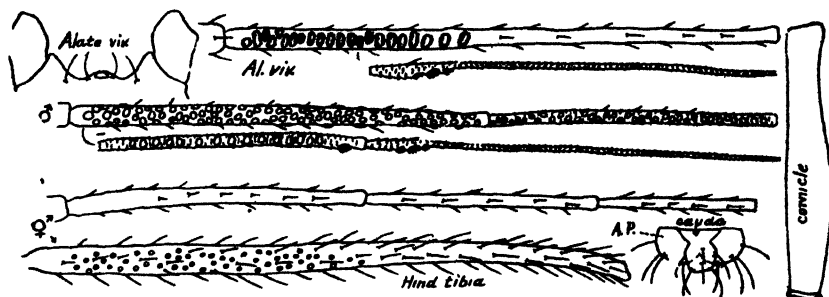


FIG. 80. *Drepanosiphum platanoides*.

Drepanosiphum braggii Gillette.

Gillette, Can. Ent., Vol. 39, p. 393, 1907.

Color.—In alatæ, pale yellow to greenish with black dashes on middle of dorsum of males; oviparæ dark olive-green, with anterior and posterior ends of body pale; legs and antennæ pale to brownish; cornicles brownish; wings hyaline; stigma pale, bordered with brown.

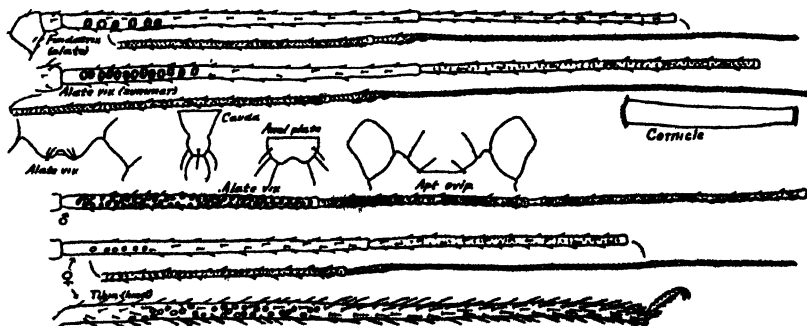


FIG. 81. *Drepanosiphum braggii*.

Measurements.—Alate summer vivipara.—Body 3 mm.; hind tibiæ 2.80 mm.; hind tarsi .19 mm.; antennæ 6.3 mm.; joint III 1.3 to 1.5 mm.; IV .93 to 1.05 mm.; V .95 to 1.10 mm.; VI .15 to .22 + 1.20 to 1.80 mm.; cornicles .60 to .80 mm. Apterous vivipara unknown.

Structural Characters.—Vertex slightly convex. Frontal tubercles strongly developed, diverging. Secondary sensoria, oval, transverse and ciliated, 6 to 13 in number on joint III of alate viviparæ; 4 to 8 on oviparæ; numerous on III, IV, and V of male. Cornicles cylindrical, somewhat constricted before flanges and gently curved outwards. Rostrum barely attaining third coxæ. Cauda knobbed. Anal plate indented. Hairs slightly capitate, short in alatae, long in apteræ. Fundatrices and males alate. Oviparæ with terminal abdominal segments prolonged to form distinct ovipositor.

Collections.—On leaves of *Acer negundo*. Taken in the state at Fort Collins; fundatrices, May 15 to June 4; alate summer viviparæ, June 20 to Oct. 2; apterous oviparæ, Sept. 5 to Nov. 2; males, Sept. 3 to Oct. 3; quite common.

Subtribe Chaitophorina.

KEY TO GENERA OF CHAITOPHORINA.

- A. Cauda knobbed.
 B. Antennae 5-jointed. (Page 915).....*Sipha*
 BB. Antennae 6-jointed. (Page 916).....*Chaitophorus*
 AA. Cauda semi-lunar, broader than long. (Page 920).....*Periphyllus*

Genus *Sipha* Pass.

Type, *Aphis glyceriae* Kalt.* (Passerini, Gli Afidi, p. 29, 1860).

Characters.—Body flat and elongate, covered with long, stout spines. Frontal tubercles, lacking. Antennæ shorter than body; 5-jointed, bearing hairs not longer than diameter of joints bearing them. Secondary sensoria circular, large. Unguis at least as long as base of VI. Cornicles truncate, short, not longer than broad. Cauda knobbed. Anal plate rounded, often hidden by terminal segment of abdomen. Living on leaves of grasses in wet places.

Sipha agropyronensis (Gillette).

Gillette, Ent. News, Vol. 22, p. 442, 1911. *Chaitophorus*.

Color.—Alate viviparæ.—Black on thorax, green on abdomen, with faint dorsal dashes. Apteræ rusty-yellow with pair of darker longitudinal stripes; legs mostly pale.

Measurements.—Apterous summer vivipara.—Body 1.8 by .7 mm.; hind tibiæ .5 mm.; hind tarsi .15 mm.; antennæ .43 to .49 mm.; joint III .17 mm.; IV .07 mm.; V .08 + .06 mm.; cornicles .03 mm. long; cauda .06 mm. Alate vivipara.—Body 1.6 to 1.9 mm.; hind tibiæ .6 mm.; antennæ .65 mm.; joint III .28 mm.; IV .10 mm.; V .11 + .07 mm.; cornicles .04 mm.; cauda .05 mm.

*Not drawn on account of impossibility of obtaining authentic specimens or drawings to copy.

Structural Characters.—Secondary sensoria circular, large, 4 to 6 on joint III in alate viviparæ; absent in apteræ. Rostrum short, not attaining third pair of coxæ. Anal plate slightly emarginate. Body surface not spinose. Mediæ either once or twice branched. Other characters as described for genus.

Collections.—On upper surface of leaves of *Agropyron glaucum*; attended by small ants. Recorded in the state at Fort Collins, Boulder, and Denver; apterous summer viviparæ, May 26 to Sept. 18; alate viviparæ, May 31 and July 23; oviparæ, Oct. 13; 21 collections; fairly common.

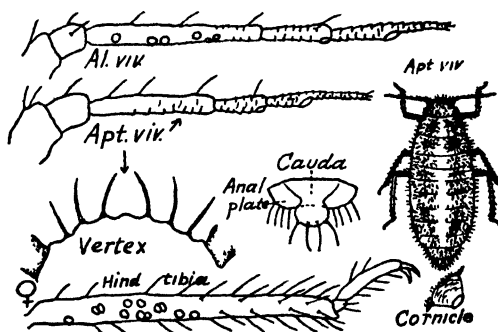


FIG. 82. *Siphia agropyronensis*.

Genus *Chaitophorus* Koch.

Type, *Aphis populi* Linn. (Koch, Die Pflanzenlaus Aphiden, p. 1, 1854).

Characters.—Frontal tubercles, absent. Antennæ 6-jointed, with circular or oval sensoria and bearing prominent hairs; unguis twice or more times as long as base. Cornicles truncate, hardly longer than broad, reticulate, and imbricated. Cauda knobbed. Anal plate rounded or indented. Fore wings with mediæ twice branched. Males either apterous or alate.

Genotype, *Chaitophorus populi* (Linnaeus). (See below.)

KEY TO SPECIES OF CHAITOPHORUS.

- A. Secondary sensoria on joint III, in alate viviparæ, arranged in a single row, not more than 10 in number.
 - B. Antennal joint IV hardly ever exceeding .15 mm. Sensoria on III in alate, 8 to 10. On *Salix*. (Page 919).....*viminalis*
 - BB. Antennal joint IV about .20 mm. Sensoria 2 to 5. On *Populus*. (Page 917).....*populella*
- AA. Secondary sensoria on joint III, in alate viviparæ, arranged in irregular double row, 12 or more in number.
 - B. Usually with sensoria on IV. (Page 918).....*populifoliae*
 - BB. Without sensoria on IV. (Page 917).....*populi*

[Genotype *Chaitophorus populi* (Linnaeus).]

Linnaeus, Edition 10, Systema Naturae, p. 453, 1758. *Aphis*.

Color.—In viviparæ.—Yellowish-green to dark green or dusky; with darker mottling; alatæ with black bands; legs greenish or ochreous; cornicles green to smoky in apteræ, black in alatæ; cauda green or dusky.

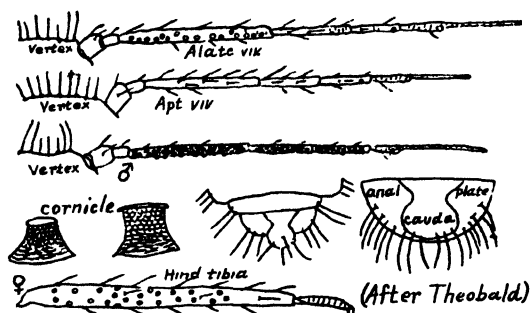


FIG. 83. *Chaitophorus populi*.

Measurements.—Apterous summer vivipara.—Body 2 to 2.5 mm. Cornicles as long as antennal joints I plus II. Antennæ shorter than body; IV a little longer than V; joint III about twice as long as IV; unguis two or three times base.

Structural Characters.—Secondary sensoria circular, scattered along almost entire joint III in alate viviparæ, 16 to 19 on III, 0 on IV; absent in apteræ. Cornicles truncate, expanded at base, reticulate distally, imbricated proximally. Hairs rather long on antennæ, longer on body. Rostrum attaining second or third coxæ. Cauda knobbed. Anal plate rounded. Males both alate and apterous.

Hosts.—Leaves of trees. (Data from description by Theobald in Aphid Gr. Brit., vol. 3, 1929).

***Chaitophorus populella* Gillette and Palmer.**

Gillette and Palmer, Ann. Ent. Soc. of Amer., Vol. 21, p. 15, 1928.

Color.—Apterous summer vivipara.—Light green to yellowish with darker green circle on dorsum of abdomen connected by lines to lateral margins of abdominal segments 1, 2 and 7; faint, dusky bands on abdomen of alate viviparæ; wings hyaline; legs pale.

Measurements.—Apterous summer viviparæ.—Body 1.5 to 2 mm.; antennæ .95 to 1.4 mm.; III .30 to .44 mm.; IV .15 to .28 mm.; V .14 to .19 mm.; VI .10 + .20 to .30 mm. Alate vivipara.—Same as aptera.

Structural Characters.—Secondary sensoria 2 to 5 on joint III in alate viviparæ, none on IV or V; absent in apteræ. Cornicles truncate,

broader at base, faintly reticulate and imbricated. Cauda knobbed. Anal plate sinuate. Males both alate and apterous.

Collections.—On leaves of *Populus occidentalis*, *angustifolia* and sp. Recorded in the state at Fort Collins, Aspen, Eckert, and Steamboat Springs; fundatrices, March 30 and April 2; apterous viviparæ, April 20 to July 23; alate viviparæ, April 20 to July 20; sexuales, Oct. 10 to 23; 25 collections; fairly common.

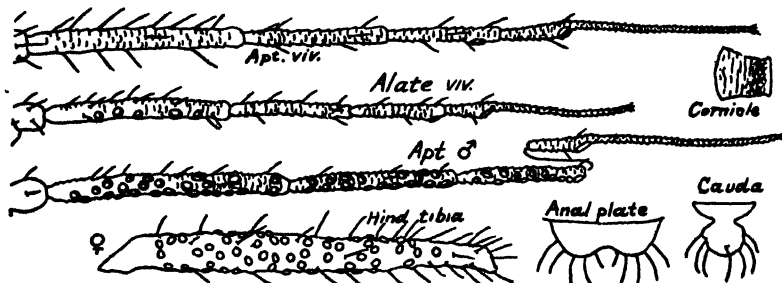


FIG. 84. *Chaitophorus populella*.

Taxonomy.—This species is distinguished from *Chaitophorus essigi* Gillette and Palmer (Syn. *Eichochaitophorus populifolii* Essig) in joint III being longer than spur; V, 1.5 to 2 times base of VI; spur, 2 to 3 times base of VI. Essig's species has spur longer than III or subequal, V not longer than base of VI and spur 3 to 4 times base of VI. From *Chaitophorus populifoliae* Oestlund it differs by fewer secondary sensoria on III, in a single row, the absence of sensoria on IV, also the absence of dark bands on abdomen of alate viviparæ.

Chaitophorus populifoliae Oestlund.

Oestlund, "Aphididae of Minn." Geo. and Nat. Hist. Sur. Minn., p. 38, 1887.

Color.—Pale green, mottled with darker green in apteræ; with blackish bands on alatæ.

Measurements.—Alate vivipara.—Body 2 to 2.20 mm.; antennæ about 1.25 to 1.5 mm.; joint III .25 to .42 mm.; IV .17 to .23 mm.; V .13 to .18 mm.; VI .10 mm. + .20 to .35 mm. Apterous summer vivipara.—Same as alata, except spur generally shorter than III, but sometimes subequal.*

*Two collections were taken August 12 and 20 at Pingree Park and Black Mesa, in which the specimens had spur never shorter, usually longer than III and sensoria 6 to 10 in a row on antennal joint III in alate viviparæ. These resemble *Chaitophorus essigi* Gillette and Palmer (Syn. *Eichochaitophorus populifolii* Essig) excepting in the dark bands of the alatæ.

Structural Characters.—Secondary sensoria circular, 12 to 21 in number, irregularly arranged on joint III, 0 to 5 on IV in alate viviparæ; absent in apteræ. Hairs on antennæ rather short, .03 to .05 mm. long. Other characters same as *Chaitophorus populifoliae* Gillette and Palmer.

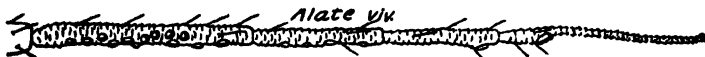


FIG. 85. *Chaitophorus populifoliae*.

Collections.—On leaves and twigs of *Populus*. Recorded on *Populus tremuloides*, throughout the state; apterous summer viviparæ, June 13 to Oct. 2; alate viviparæ, June 22 to Sept. 25; sexuales, Oct. 2; 12 collections; rather common.

Chaitophorus viminalis Monell.

Monell, Bul. U. S. Geol. & Geog. Terr. Surv. V, No. 1, p. 31, 1879.

Color.—Apteræ.—Green, brown, or yellow, often with a pair of broad black vittæ extending laterally. Alatæ green with bands on all abdominal segments.

Measurements.—Apterous summer vivipara.—Body 1.5 to 2 mm.; antennæ about half as long as body; joint III .25 to .29 mm.; IV .11 to .16 mm.; V .09 to .13 mm.; VI .09 + .15 to .30 mm.

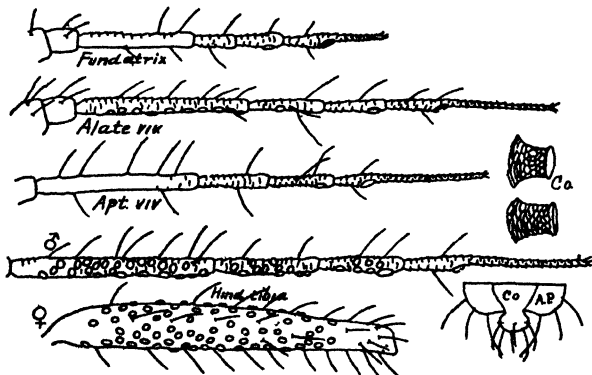


FIG. 86. *Chaitophorus viminalis*.

Structural Characters.—Secondary sensoria 8 to 10 on III in alate viviparæ, 0 to 2 or rarely 4 on IV, none on V. Hairs prominent and spine-like on antennæ and body. Cornicles reticulate, often indistinctly, on distal .6 or .75, remainder imbricated. Cauda knobbed. Anal plate sinuate. Males alate or apterous (?).

Collections.—On leaves of *Salix* sp. Recorded generally throughout the state; fundatrix, April 28; apterous summer viviparæ, May 21 to Oct. 20; alate viviparæ, May 29 to Oct. 20; oviparæ, Oct. 2 to Nov. 7; males, Oct. 2 to 22; numerous collections; very common.

Taxonomy.—This species is separated from *Chaitophorus nigræ* Oestlund, by the absence of sensoria on antennal joint V, 0 to 2, rarely 4, on IV, and rarely over 10 on III, while *nigræ* has 10 to 14 on III, 4 to 6 on IV, and 1 to 4 on V, in 10 examples kindly sent by Dr. Oestlund. Examples of *viminalis* sent by Monell agree with Colorado specimens. Apteræ of *nigræ* are more reticulate on dorsum than *viminalis*, but this is often difficult to discern.

[Genus *Periphyllus* Van der Hoeven.]

Type, *Periphyllus testudo* Van der Hoeven, 1863 (= *testudinatus* Thornton, 1852). (Van der Hoeven, Tijds. voor. Ent., Vol. 6, p. 7, 1863).

Characters.—Frontal tubercles absent. Antennæ 6-jointed, except in dimorph, with circular to oval sensoria and prominent hairs; unguis, not shorter than base. Cornicles short, truncate, usually imbricated or reticulate. Cauda and anal plate, rounded. Fore wings with mediæ twice branched. Males alate or apterous.

Genotype, *Periphyllus testudinatus* (Thornt.). (See below.)

KEY TO SPECIES OF PERIPHYLLUS.

- A. Unguis subequal with base of VI. On *Salix*.
 - B. Length 2.50 to 3 mm. Never blackish. Veins not smoky. On bark near roots. (Page 925)..... **salicicorticis**
 - BB. Length 2 to 2.50 mm. Dark brown to blackish. Veins smoky. On bark of twigs. (Page 922)..... **macrostachyæ**
- AA. Unguis longer than base of VI. Not on *Salix*.
 - B. Hairs on vertex shorter than .10 mm. On *Populus*. (Page 924). **populicola**
 - BB. Hairs on vertex longer than .10 mm. On *Acer*.
 - C. Unguis longer than twice as long as base; hairs on antenna joint III as long as twice diameter of joint. On *Acer negundo*.
 - D. Sensoria on III in alatae less than 15. (Page 923)..... **negundinis**
 - DD. Sensoria on III in alatae more than 15. (Page 920)..... **testudinatus**
 - CC. Unguis less than twice as long as base. Hairs on antennal joint III, hardly as long as diameter of joint. On *Acer glabrum*. (Page 921), **brevispinosus**

[Genotype *Periphyllus testudinatus* (Thornt.).]

Thornton, Proc. Entom. Soc. London, n. s., (2), p. 78, 1852. *Phyllophorus*. Van der Hoeven, Tijdscher, Ent. Ned, Ent. Ver., VI, pp. 1-7, 1863.

Color.—Dark green to gray.

Measurements.—Body 3 mm.; antennæ shorter than body; unguis 2 or 3 times as long as base but shorter than III.

Structural Characters.—Secondary sensoria circular, about 20, scattered along entire length of III in alatae. Cornicles truncate, finely reticulate on slightly dilated base, which is imbricated or rugose.

Cauda half-moon shaped. Anal plate entire. Flabellate dimorphs produced, bearing six rows of dorsal plates. Flabellæ broadly rounded. Males alate.

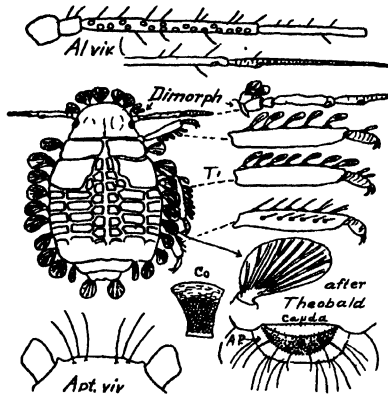


FIG. 87. *Periphyllus testudinatus*.*

Host.—Leaves of *Acer* (Description after Theobald in Aphid. Gr. Brit., Vol. 3, 1929.) Not recorded in the state.

***Periphyllus brevispinosus* Gillette and Palmer.**

Gillette and Palmer, Ann. Ent. Soc. of Am., Vol. 23, p. 546, 1930.

Color.—Brown, with dark and light mottling in apteræ, and dusky bands in alatæ; cornicles yellow; legs mostly yellow; wings hyaline.

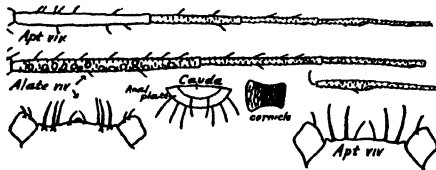


FIG. 88. *Periphyllus brevispinosus*.

Measurements.—Apterous summer vivipara.—Body 2.40 mm. by 1.50 mm.; hind tibiæ .85 mm.; antennæ 1.30 mm.; joint III .36 to .47 mm.; IV .22 to .30 mm.; V .20 to .23 mm.; VI .14 mm. + .18 to .20 mm.; cornicles .10 mm.; spines on body, .10 to .12 mm. Alate vivipara.—Length 2.25 mm.; hind tibiæ 1 mm.; antennæ 1.55 mm.; joint III .43 to .55 mm.; IV .28 to .40 mm.; V .25 to .30 mm.; VI .14 mm. + .17 to .22 mm.; cornicles .11 mm.; cauda .14 mm. Hairs on body and vertex spine-like, .13 mm. long and heavy; on antennæ, much finer, not over .04 mm. long.

*Hairs on antennæ are erroneously drawn, only half as long as in Theobald's drawing.

Structural Characters.—Secondary sensoria circular to oval in irregular double row, 11 to 19 in number on III in alate viviparae. Rostrum barely attaining second pair of coxae. Mediæ twice branched. Cauda and anal plate rounded.

Collections.—On leaves of *Acer glabrum*. Recorded in the state at Idaho Springs; alate and apterous summer viviparae, June 17, 1926; one collection; rare, but abundant on trees found infested.

Types in U. S. Nat. Mus., Cat. No. 42816; paratypes in collection of Colo. Agr. Exp. Sta.

***Periphyllus macrostachyae* (Essig).**

Essig, Pom. Coll. Jour. Ent. 4, p. 727, 1912. *Symydobius*.

Color.—Apterous vivipara.—Reddish-brown to blackish; alatae with black bands, lighter area about cornicles; cornicles yellow. Fore wings, slightly smoky, veins narrowly bordered with brown, stigma short, with depression at distal end, with light streak extending from subcosta. Immature forms pale or reddish-yellow marked by reddish-brown as follows: band on first abdominal segment, a pair of dorso-lateral longitudinal lines from prothorax to fourth abdominal segment, and ring enclosing pale area around cornicles and connecting anteriorly with band on first abdominal segment; thus making pale "Y" pattern on dorsum, similar to *P. populicola*.

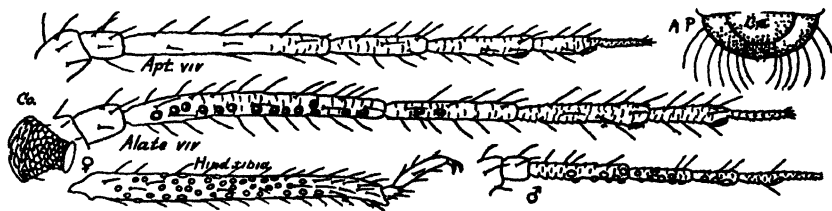


FIG. 89. *Periphyllus macrostachyae*.

Measurements.—Apterous summer vivipara.—Body 1.5 to 2 mm. by .8 to 1 mm.; hind tibiae .7 to .9 mm.; hind tarsi .14 mm.; antennae .75 to 1 mm.; joint III .30 to .34 mm.; IV .15 mm.; V .13 to .17 mm.; VI .10 + .07 to .12 mm.; cornicles .06 to .07 mm.; cauda .05 mm. Alate vivipara.—Body 1.5 to 2.5 mm.; hind tibiae 1 mm.; hind tarsi .16 mm.; antennae .96 to 1.3 mm.; joint III .38 to .50 mm.; IV .17 to .23 mm.; V .15 to .22 mm.; VI .09 to .12 + .10 to .12 mm.; cornicles .07 mm.; cauda .05 mm.

Structural Characters.—Hairs on antennae about 1.5 as long as diameter of joints bearing them. Secondary sensoria circular, with rims, arranged in single row along entire length of III, 9 to 14 in number, 1 to 3 on IV; and 0 to 1 on V in alatae; absent in apterae. Cornicles truncate, broader than long, with faint reticulations distally, imbricated and bearing 4 to 6 short hairs basally. Cauda semicircular. Anal

plate rounded. Hairs spine-like and heavy. Rostrum attaining between second and third coxæ. Males apterous.

Collections.—On bark of twigs of *Salix* sp. Recorded in the state at Fort Collins, Bellvue, Boulder, Rocky Ford, and Englewood; apterous viviparæ, May 2 to Aug. 21; alate viviparæ, May 9 to Aug. 21; oviparæ, Oct. 14 to 25; males, Oct. 14; 19 collections; rather common.

Taxonomy.—This form differs from *P. macrostachya* (Essig) according to the original description and two paratypes kindly sent by Professor Essig, in the shorter rostrum. As no other specific differences are apparent it seems best not to erect a new species at present.

***Periphyllus negundinis* (Thomas).** .

Thomas, Ill. State Lab. Nat. Hist. Bul. 2, p. 10, 1877. *Chaitophorus*.

Color.—In summer vivipara.—Yellowish or sap-green to apple-green; legs pale to dusky; cornicles pale; sexuales, olive-green to brownish.

Measurements.—Apterous summer vivipara.—Body 2 to 2.5 mm. by 1 mm.; hind tibiæ .70 to 1.1 mm.; hind tarsi .15 mm.; antennæ 1 to 1.5 mm.; joint III .23 to .44 mm.; IV .20 to .30 mm.; V .15 to .27 mm.; VI .08 to 12 + .20 to 34 mm.; cornicles .10 mm.; cauda .07 mm. Alate vivipara.—Same as aptera or slightly larger.

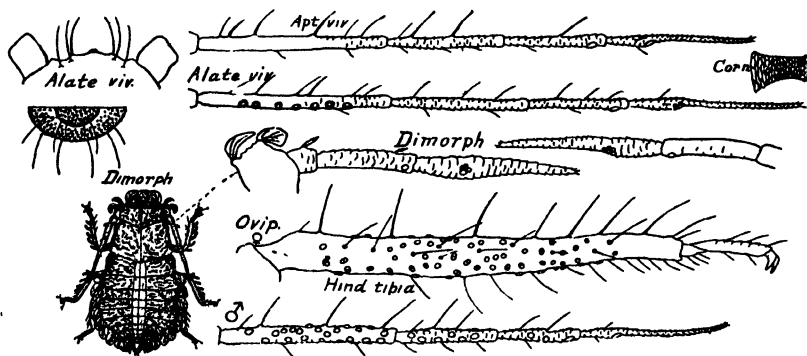


FIG. 90. *Periphyllus negundinis*.

Structural Characters.—Hairs spine-like, .12 to .16 mm. long on head, and .08 mm. on antennal joint III. Secondary sensoria circular with narrow rims, 3 to 9 in single row, along most of III in alate viviparæ; absent in apteræ. Cornicles truncate, slightly narrowed in middle, reticulate throughout. Cauda semicircular. Anal plate entire. Rostrum barely attaining second pair of coxæ. Dimorphs produced with flabellæ more or less pointed, and with only the median two rows of dorsal plates, remainder of dorsum rugose. Males apterous.

Collections.—On leaves and twigs of *Acer negundo*. Recorded in the state at Fort Collins, Meeker, Ridgway, Colorado Springs, and Ouray; fundatrices, March 12 to May 4; apterous summer viviparae, May 10 to Oct. 31; alate viviparae, May 4 to Sept. 27; oviparae, Oct. 3 to Nov. 16; males, Oct. 3 to 15, dimorphs, May 4 to Aug. 19; 70 collections; very common.

***Periphyllus populicola* (Thos.).**

Thomas, Ill. State Lab. Nat. Hist. Bul. 2, p. 10, 1877. *Chaitophorus*.

Color.—Head brown; body yellowish or greenish with dusky bands and lateral spots in alatae; in apterae rather solid mottling of brownish, leaving only a pale V-shaped area on dorsum, pale ring about cornicles and pale median area on terminal abdominal segments; cornicles pale. Fore wings with veins heavily bordered with smoky; hind wings with veins but faintly bordered; young rusty anteriorly and with median dorsal spot on abdomen, remainder of abdomen pale greenish-yellow with pale median "V" pattern on thorax.

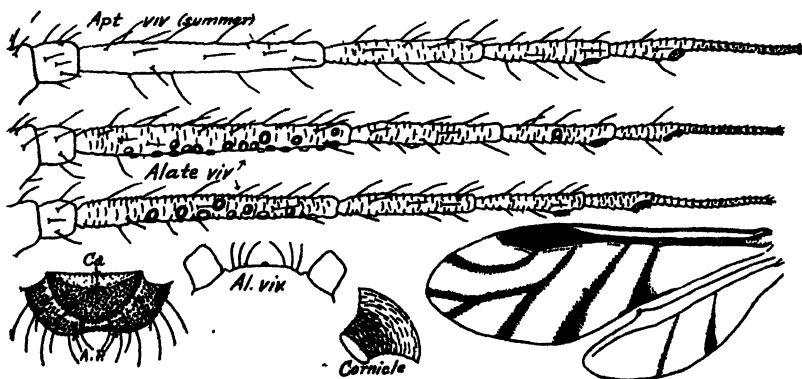


FIG. 91. *Periphyllus populicola*.

Measurements.—Apterous summer vivipara.—Body 2 to 2.5 mm.; hind tibiae .9 to 1 mm.; hind tarsi .16 to .19 mm.; antennae 1.3 mm.; joint III .30 to .39 mm.; IV .17 to .25 mm.; V .16 to .21 mm.; VI .10 to .13 + .17 to .20 mm.; cornicles .09 mm.; cauda .05 mm. Alate vivipara.—Same as aptera or with slightly longer appendages, especially antennal joint III.

Structural Characters.—Hairs on antennae about as long as diameter of joint bearing them. Secondary sensoria circular, with narrow rims, 9 to 24 scattered along entire length of III, 0 to 6 on IV, 0 to 2 on V in alatae; absent in apterae. Cornicles truncate, short, dilated at base, imbricated, sometimes showing faint reticulation on distal half. Rostrum hardly attaining second pair of coxae.

Collections.—On leaves and twigs of *Populus balsamifera*, *acuminata*, *occidentalis*, and *angustifolia*. Recorded throughout the state; fundatrices, April 30 to May 23; apterous viviparæ, May 7 to Oct. 23; alate viviparæ, May 29 to Oct. 20 (Dimorphs were received from the late Mr. Monell, taken at St. Louis, Mo., June 19, 1907); oviparæ, Oct. 2 to 31; alate males, Oct. 9 to 31; 85 collections; very common.

Taxonomy.—This species has been used as type of the genus *Neothomasia* Baker, but the writers do not consider the differences to be of generic importance.

***Periphyllus populicoli* var. *bruneri* (Williams).**

Williams, "Aphididae of Nebraska," University Studies, Vol. 10, p. 25, 1911.
Chaitophorus.

Characters.—Same as typical *P. populicola* excepting that the coloring is much darker. Apteræ polished dark-brown or black with segment lines pale and little or no trace of the pale "V" or "Y" pattern; legs black throughout. Alatæ with head and thorax dark-brown or black; abdomen, yellowish to brown, with dark bands. Cornicles pale in both forms. Fore wings with veins conspicuously bordered with blackish. Hind wings with media and cubitus faintly bordered. Immature forms more rusty-brown and showing the "Y" pattern.

Collections.—On leaves and twigs of *Populus tremuloides* rarely on *Populus balsamifera candicans*. Recorded in the state throughout the mountains wherever the host plant occurs; apterous viviparæ, June 21 to Sept. 2; alate viviparæ, June 21 to Aug. 25; 18 collections; common.

***Periphyllus salicicorticis* (Essig) (?).**

Essig, Pom. Coll. Jour. Ent. 4, p. 731, 1912. *Symydobius*.

Color.—Dingy or greenish-yellow, or rusty-brown with darker dashes in alatæ; apteræ with dashes often broken but with light areas about cornicles; cornicles pale, veins of fore wing rather heavy and brown, but hardly smoky.

Measurements.—Apterous summer vivipara.—Body length 2.3 mm.; width 1.3 mm.; hind tibiæ .90 mm.; hind tarsi .14 mm.; antennæ 1 mm.; joint III .33 to .37 mm.; IV .14 mm.; V .14 mm.; VI .10 + .09 mm.; cornicles .07 mm.; cauda .07 mm. Alate vivipara.—Same as aptera or slightly larger.

Structural Characters.—Secondary sensoria 10 to 16 on III, 0 to 2 on IV in alatæ*; absent in apteræ. Cornicles truncate, broader at

*Three alate viviparæ were taken on which the secondary sensoria were not evident on the antennæ, but in all other characters they appear to agree with the other examples.

base, shorter than broad. Cauda semi-circular. Anal plate entire. Hairs moderately heavy, spine-like. Rostrum attaining first or second abdominal segment. Males apterous.

Collections.—On bark of *Salix* sp., at or beneath the surface of the ground. Recorded in the state at Fort Collins, Denver, Antonito, and Rocky Ford; fundatrices, May 2; apterous summer viviparæ July 1 to Sept. 23; alate viviparæ, May 28 and Aug. 11; oviparæ and males, Oct. 10 to 31; 14 collections; rather common.

Taxonomy.—This species is exceedingly difficult to separate from the form here determined as *P. macrostachyæ* (Essig). Indeed the lighter coloration and the habitat at the surface of the ground seem to be the only distinguishing characters. It seems likely that further biological study may prove both forms to belong to one species.

Subtribe **Fullawayina.**

Characters.—Frontal tubercles lacking. Antennæ conspicuously hairy. Cauda semi-lunar. Anal plate rounded. Cornicles lacking. Differing from *Chaitophorini* in the absence of cornicles.

Genus **Fullawayia** Essig.*

Type, *Fullawayia saliciradicis* Essig. (Essig, Pom. Coll. Jour. Ent., Vol. 4, p. 716, 1912).

Characters.—Frontal tubercles lacking. Ocular tubercles present. Lateral tubercles well developed. Body and all appendages conspicuously hairy. Cornicles lacking. Cauda semi-lunar, broader than long.

Genotype **Fullawayia saliciradicis** Essig.

Essig, Pom. Coll. Jour. Ent. 4, p. 737, 1912.

Color.—In all forms.—Yellowish-brown to brownish-yellow to blackish; finely pulverulent throughout; legs sordid yellow; wings hyaline.

Measurements.—Apterous summer vivipara.—Body 2 to 3 mm.; hind tibiae .12 to .17 mm.; hind tarsi .22 to .26 mm.; antennæ 1.6 to 2 mm.; joint III .42 to .48 mm.; IV .30 to .35 mm.; V .30 to .36 mm.; VI .20 to .24 + .32 to .35 mm. Alate vivipara.—Same as aptera.

*Borner (1930) considers that this genus should be *Pulvius* Sanborn (Kans. Univ. Bul., Apr., p. 225, 1906). The writers are unable to agree with this opinion. The eyes in Sanborn's species are rudimentary, consisting of but three ocelli and the rostrum is once and a half the length of the body. In *saliciradicis* Essig the eyes are normal and compound, and the rostrum is subequal with the body in length. It appears probable that Sanborn had immature forms (only 3 in ants' nest) and it is impossible to determine to which of several genera they may have belonged.

Structural Characters.—Hairs pointed, numerous; on antennæ .05 to .06 mm. long, about as long as diameter of joint bearing them; on vertex and body .08 to .10 mm.; on hind tibiæ .04 to .06, shorter than diameter of tibiæ. Secondary sensoria small, circular, arranged in an irregular row on joint III, 13 to 21 in alate viviparæ; 3 to 7 in apteræ. Lateral tubercles very large. Rostrum obtuse, about the same length as body. Mediæ twice branched. Other characters as given for genus.

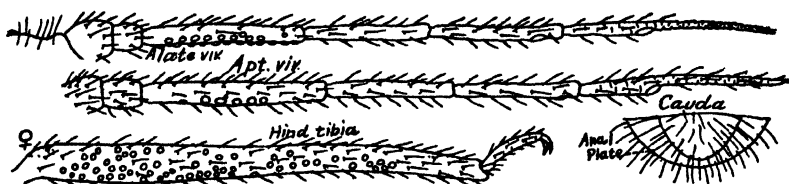


FIG. 92. *Fullawayia saliciradicis*.

Collections.—On roots of *Salix laevigata*. Recorded in the state at Fort Collins and Boulder; apterous summer viviparæ, June 4 to Sept. 24; alate viviparæ, June 10 to Sept. 7; oviparæ, Oct. 18 to Nov. 4; males, Oct. 18; 11 collections; rather rare.

Subtribe **Pterocommina**.

Characters.—Differs from *Chailophorini* in longer cornicles, from *Lachnini* in shorter legs, pronounced lateral tubercles, and longer cornicles. Living on bark of trees.

KEY TO GENERA OF PTEROCOMMINA.

- A. Cornicles cylindrical. (Page 927).....**Pterocomma**
- AA. Cornicles swollen.
- B. Cornicles with flange. (Page 931).....**Clavigerus**
- BB. Cornicles without flange. (Page 929).....**Plocamaphis**

Genus **Pterocomma** Buckton.

Type, *Pterocomma pilosa* Buckton.* (Buckton, Monog. Br. Aphides, Vol. 2, p. 142, 1879).

Characters.—Cornicles cylindrical, with distinct flange. Antennæ shorter than body, bearing hairs which are pointed and longer than diameter of joints. Cauda semi-lunar. Anal plate entire. Body conspicuously hairy. Lateral tubercles well developed. Ocular tubercles present. Living on bark of *Salix* and *Populus*. Only two species recorded from the state.

KEY TO SPECIES OF PTEROCOMMA.

- A. Unguis usually shorter than half of III. Cornicles cylindrical. (Page 928).....**populea**
- AA. Unguis usually longer than half of III. Cornicles slightly swollen. (Page 928).....**beulahensis**

*Not figured on account of inability to obtain either authentic specimens or drawings.

Pterocomma beulahensis (Ckl.).

Cockerell, Can. Ent. XXXVI, p. 263, 1904. *Cladobius*.

Color.—In vivipara.—Yellowish-olive-green; wings hyaline.

Measurements.—Apterous summer vivipara.—Body 3 to 4 mm.; hind tibiae 1.9 to 2 mm.; hind tarsi .20 to .25 mm.; antennae 1.9 to 2 mm.; joint III .50 to .65 mm.; IV .32 to .40 mm.; V .30 to .38 mm.; VI .15 to .20 + .30 to .35 mm.; cornicles .20 to .27 mm. Alate vivipara.—Same as aptera.



FIG. 93. *Pterocomma beulahensis*.

Collections.—On *Populus tremuloides*, on bark. Recorded in the state near Fort Collins, Pingree Park, Idaho Springs, and Lost Lake; fundatrices, June 11; apterous summer viviparae, June 30 to July 5; alate viviparae, June 22 to July 5; 6 collections; rather rare.

Taxonomy.—Differs from *P. populea* in longer unguis, usually over half length of III, 1.5 to twice base of VI, and 1.25 to 1.5 times cornicles; and in the cornicles, which though practically cylindrical in some views, appear slightly but distinctly swollen in other views. These differences would hardly seem sufficient to distinguish a separate species were it not for the difference in host plant.

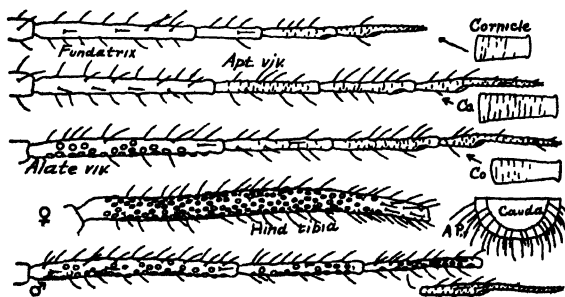


FIG. 94. *Pterocomma populea*.

Pterocomma populea (Kaltenbach).

Kaltenbach, Mon. der Pflanzenlause, p. 116, 1843. *Aphis*.

Color.—Yellowish-olive-brown, slightly pulverulent; wings hyaline.

Measurements.—Apterous summer vivipara.—Body 3 to 4 mm.; hind tibiae 1.2 to 1.8 mm.; hind tarsi .20 mm.; antennae 1.2 to 1.7 mm.;

joint III .45 to .50 mm.; IV .24 to .27 mm.; V .21 to .27 mm.; VI .12 to .14 + .17 to .23 mm.; cornicles .20 to .24 mm. Alate vivipara.—Same as aptera or with slightly longer appendages.

Structural Characters.—Hairs pointed, numerous. Secondary sensoria 19 to 26 on joint III in alate viviparæ; 0 in apteræ. Rostrum attaining abdomen. Cornicles cylindrical, faintly rugose proximally. Males alate.

Collections.—On bark of *Populus balsamifera* in Colorado. Recorded at Fort Collins, Estes Park, and Longmont; fundatrices, April 19 to May 8; apterous summer viviparæ, May 30 to Oct. 25; alate viviparæ, May 6 to Oct. 10; oviparæ, Oct. 10 and Nov. 13; males, Sept. 18 (in Estes Park); 14 collections; fairly common.

Genus *Plocamaphis* Oestlund.*

Type, *Melanoxanthus flocculosus* Weed. (Oestlund, "A Synoptical Key to the Aphididae of Minn." 19th Rept. St. Ent. Minn., p. 122, 1922).

Characters.—Frontal tubercles lacking. Antennæ conspicuously hairy. Hairs pointed. Secondary sensoria circular; usually present in apteræ. Rostrum obtuse, terminal joint indeterminate. Cornicles longer than broad, swollen, with tip contracted, opening small and without flange. Cauda semi-lunar or triangular, broader than long. Anal plate entire. Body conspicuously hairy, and flocculent. Lateral tubercles pronounced. Ocular tubercles, small. Living on bark of trees.

Genotype, *Plocamaphis flocculosa* (Weed). (See below.)

KEY TO SPECIES OF PLOCAMAPHIS.

- A. Cornicles large, equaling hind tarsi in length. (Page 929).....**flocculosa**
 AA. Cornicles minute, much shorter than hind tarsi. (Page 930).....**braggii**

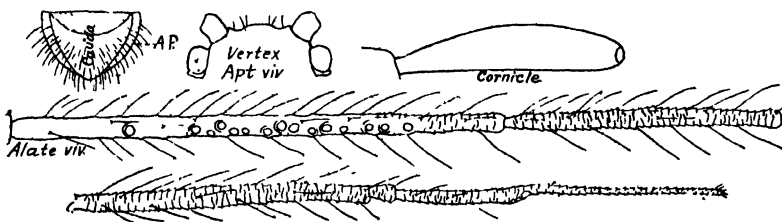


FIG. 95. *Plocamaphis flocculosa*.

Genotype *Plocamaphis flocculosa* (Weed).

Weed, Insect Life, III, p. 291, 1891. *Melanoxanthus*.

Color.—Dull yellowish-brown with a pair of longitudinal rows of black areas; very flocculent; cornicles bright orange; legs light brownish

*Takahashi (Pr. Ent. Soc. Wash., Vol. 32, p. 7, 1930) considers this genus as a synonym of *Clavigerus*.

to dusky. Wings hyaline, except cubital and anal veins on fore wings which are slightly smoky.

Measurements.—Apterous summer vivipara.—Body 2.5 to 3.5 mm.; hind tibiae 2 to 3 mm.; hind tarsi .30 to .35 mm.; antennae 2.65 to 3 mm.; joint III .75 to 1.05 mm.; IV .50 to .60 mm.; V .50 to .63 mm.; VI .20 to .28 + .28 to .35 mm.; cornicles .35 to .40 mm. Alate vivipara.—Same as aptera, except cornicles .25 to .35 mm.

Structural Characters.—Hairs pointed, numerous, .08 to .10 mm. long; on antennae twice as long as diameter of antennae; on hind tibiae about as long as diameter of tibiae. Secondary sensoria circular, small, in apterae usually 10 to 17, occasionally 0 on joint III; in alatae 17 to 25 in irregular double row on III. Rostrum obtuse, attaining about to third coxae. Cornicles smooth, swollen along entire length, contracted at both ends, held against body. Mediae twice forked. Cauda triangular, bearing many hairs. Males apterous.

Collections.—On bark of *Salix*. Recorded in the state at Fort Collins and Eldora; fundatrices, April 16; apterous summer viviparae, July 16 to Aug. 8; alate viviparae, June 7 to Aug. 8; sexuales, Oct. 23; 7 collections; rare.

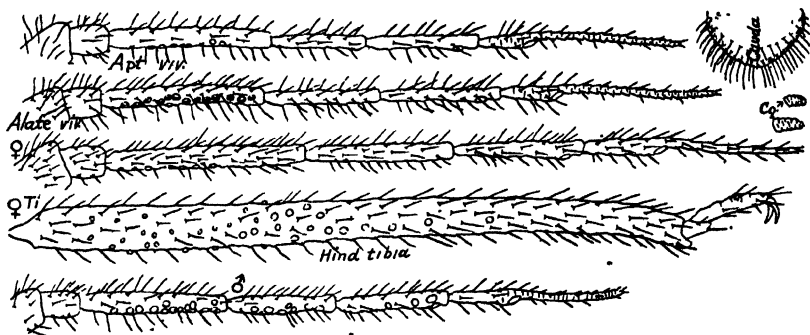


FIG. 96. *Pilocamaphis braggii*.

Pilocamaphis braggii Gillette and Palmer.

Gillette and Palmer, Ann. Ent. Soc. of Am., Vol. 22, p. 1, 1929.

Color.—In all forms.—Yellowish to dusky-brown, hairy; wings hyaline.

Measurements.—Apterous summer vivipara.—Body 2.5 to 3 mm.; hind tibiae 1.5 to 1.8 mm.; hind tarsi .20 mm.; antennae 1.5 to 1.9 mm.; joint III .43 to .50 mm.; IV .25 to .32 mm.; V .29 to .33 mm.; VI .16 to .18 + .30 to .41 mm.; cornicles .05 to .06 mm.; cauda .15 mm.

Structural Characters.—Secondary sensoria small, with rims, and circular, 4 to 6 on III in apterae, 10 to 14 in irregular row in alate viviparae. Hairs pointed, numerous; on antennae erect, .07 mm. long, slightly longer than diameter of antennal joints; on hind tibiae about

same length, but slightly shorter than diameter of tibiae; on body .08 to .10 mm. long. Lateral tubercles conspicuous on prothorax and all abdominal segments except the eighth. Ocular tubercles inconspicuous. Cornicles minute, difficult to discern, slender, cylindrical, hardly swollen, curved inward, without flange and constricted at opening, imbricated. Rostrum obtuse, attaining abdomen. Fore wings, with mediae once branched in the 4 examples taken. Males apterous with numerous sensoria on joints III, IV, and V of antennae.

Collections.—On roots of *Salix*. Recorded in the state at Fort Collins and Boulder; fundatrices, May 17; apterous summer viviparae, Sept. 7 to 22; alate viviparae, Sept. 7; oviparae, Sept. 22 to Nov. 5; males, Oct. 18 to Nov. 5; 5 collections; rare.

Taxonomy.—This species resembles very closely *Fullawaya saliciradicis* Essig, but differs in the presence of minute cornicles.

Genus *Clavigerus* Szepligeti.*

Type, *Aphis salicis* Linnaeus. (Szepligeti, Rovaraszati Lapok I, p. 4, 1883).

Characters.—Body and appendages conspicuously hairy. Hairs, pointed. Lateral tubercles, well developed. Vertex, convex. Frontal tubercles lacking. Antennae shorter than the body. Secondary sensoria circular or oval. Cornicles more or less swollen and with flange. Cauda semi-lunar, broader than long. Anal plate entire. Living on bark of trees.

Genotype, *Clavigerus salicis* (Linnaeus). (See below.)

KEY TO SPECIES OF CLAVIGERUS.

- A. Cornicles much more than twice as long as wide; proximal fourth not swollen.
- B. Cornicles swollen at middle to twice diameter at base, bright orange in color. On *Salix*. (Page 931).....*salicis*
- BB. Cornicles swollen less than 1.5 times diameter at base.
- C. Unguis 1.6 to 2 times base of VI. On *Salix*. (Page 932).....*bicolor*
- CC. Unguis 1 to 1.5 times base of VI. On *Populus*. (Page 933).....*populifoliae*
- AA. Cornicles about twice as long as wide; swelling beginning at base. On *Populus* and *Salix*. (Page 934).....*smithiae*

Genotype *Clavigerus salicis* (Linnaeus).

Linnaeus, Edition 10, Systema Naturae, p. 453, 1758. *Aphis*.

Color.—In all forms.—Bluish to greenish-black with pattern of pulverulence on median and intersegmental lines and lateral and dorso-lateral areas; cornicles bright orange; legs brownish-yellow; wings hyaline; veins bordered with smoky.

*This is the genus generally known as *Melanoxanthium* Schouteden, 1901. *Clavigerus* was erected in 1883 by Szepligeti with type species "*Cl. salicis* Kaltendach," which he mentions to be the same as *Aphis salicis* Linnaeus. (See Schumacher. Zoologischer Anzeiger, 1921 and 2).

Measurements.—Apterous summer vivipara.—Body 3.3 to 4 mm.; hind tibiae 2.2 to 2.5 mm.; hind tarsi .25 mm.; antennae 2 to 2.2 mm.; joint III .70 to .75 mm.; IV .40 to .50 mm.; V .35 to .38 mm.; VI .20 to .23 + .18 to .21 mm.; cornicles .50 to .55 mm. Alate vivipara.—Same as aptera.

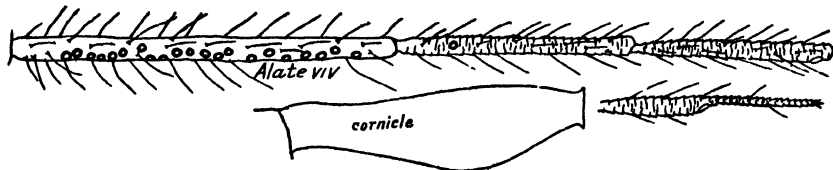


FIG. 97. *Clavigerus salicis*.

Structural Characters.—Hairs pointed, numerous; on vertex .10 to .11 mm.; on antennae .07 to .10 mm., from once to twice as long as diameter of antennae. Rostrum obtuse, attaining from second to third coxae. Secondary sensoria small, circular, scattered in irregular double row along entire length of joint III, about 20 in number in alate viviparae; 2 or 3 to 12 in apterae. Cornicles smooth, much swollen distad of center, contracted just before flange, greatest diameter twice diameter at base. Fore wings with mediae twice branched.

Collections.—On bark of *Salix* sp. Recorded in the state at Fort Collins, Boulder, Eldora, Colorado Springs, Log Cabin, and Gunnison; fundatrices, May 25 to 29; apterous summer viviparae, May 28 to Oct. 16; alate viviparae, May 28 to Aug. 6; sexuales, Oct. 16; 17 collections; hardly common.



FIG. 98. *Clavigerus bicolor*.

***Clavigerus bicolor* (Oestlund).**

Oestlund, "Aphididae of Minn.," Geol. and Nat. Hist. Sur. Minn., p. 36, 1887.
Melanoxanthus.

Color.—In all forms.—Reddish-brown to dusky greenish-yellow, with slight powdery markings on intersegmental lines; legs, cornicles and antennae yellowish; young pale greenish; wings hyaline.

Measurements.—Apterous vivipara.—Body 3 to 4 mm.; hind tibiae 1.5 to 2 mm.; hind tarsi .20 to .22 mm.; antennae 1.5 to 2 mm.; joint III .40 to .50 mm.; IV .25 to .30 mm.; V .25 to .29 mm.; VI .12 to .18 + .24 to .30 mm.; cornicles .25 to .30 mm. Alate viviparae.—Same as aptera or slightly longer.

Structural Characters.—Hairs numerous; on antennae nearly erect, .07 to .08 mm. long, and 1.5 to 2 times as long as diameter of antennae

on vertex .10 mm. long. Secondary sensoria circular, from 11 to 24 in irregular row on joint III in alate viviparæ; absent in apteræ. Cornicles 4 times as long as wide, somewhat swollen in distal half, very slightly imbricated, flange distinct. Rostrum obtuse, hardly attaining second coxæ. Lateral tubercles well developed. Mediæ twice forked. Males alate.

Collections.—On bark of *Salix* sp. Recorded in the state at Fort Collins, Greeley, Salida and Denver; fundatrices, April 2 to 18; alate and apterous summer viviparæ, April 2 to Nov. 6; sexuales, Oct. 2 to Nov. 10; 70 collections; extremely common and abundant.

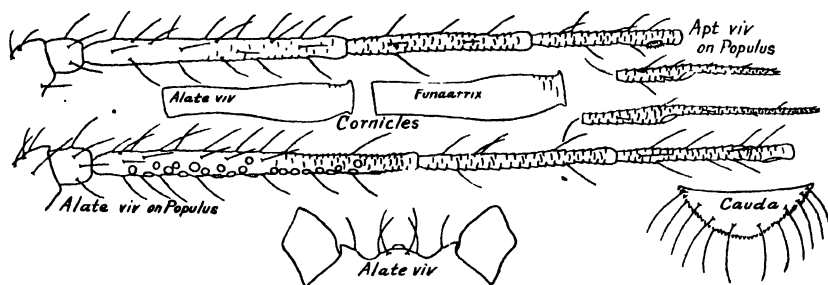


FIG. 99. *Clavigerus populifoliae*.

Clavigerus populifoliae (Fitch).

Fitch, Rept. Reg. Univ. State N. Y. Cab. Nat. Hist., p. 66, 1851. *Aphis*.

Color.—Same as in *Cl. bicolor*.

Measurements.—The only apparent difference seems to be in measurements of antennal joints. The fundatrices of the two forms appear to be indistinguishable. Apterous summer vivipara.—Antennal joint III .60 to .68 mm.; IV .35 to .40 mm.; V .33 to .37 mm.; VI .18 to .22 + .26 to .32 mm.; cornicles .33 to .40 mm.; hind tarsi .20 to .24 mm. Alate vivipara.—Same as aptera. All other characters appear to be as in *Cl. bicolor*.

Collections.—On bark of *Populus* sp. Recorded in the state at Fort Collins; fundatrices, April 18; apterous summer viviparæ, April 28 to June 8; alate viviparæ, May 8 to June 8 and Oct. 10; oviparæ, Oct. 27.

Taxonomy.—The forms here determined as *Clavigerus bicolor* and *populifoliae* are very closely related and really rank intermediate between *bicolor* Oestlund and *populifoliae* Fitch, according to Baker's measurements of unguis (Can. Ent. Vol. 48, p. 284, 1916). The unguis in summer viviparæ hardly

ever attains twice and sometimes hardly more than once and a half times base of VI in Colorado examples from *Salix*, and varies from once to once and a half times base in Colorado examples from *Populus*, but is subequal with base in fundatrices of both forms. There is sufficient overlapping so that no distinct line can be drawn and very few reach the extremes given by Baker for the two species. Possibly these forms are but variations of a single species. At present it seems best to determine the *Salix* form as *Cl. bicolor*, and the *Populus* form as *Cl. populifoliae* until biological tests succeed in settling either the identity or the separate status of these forms.

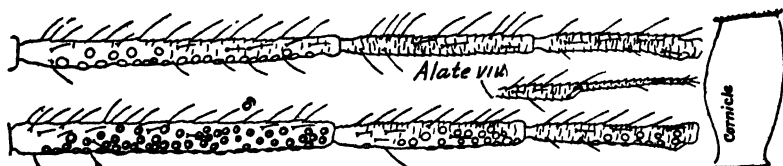


FIG. 100. *Clavigerus smithiae*.

***Clavigerus smithiae* (Monell).**

Monell, Bul. U. S. Geol. & Geog. Surv. Terr. V, No. 1, p. 32, 1879. *Chaitophorus*.

Color.—All forms.—Dark brown, with slight powder which gives a bluish effect, legs, antennæ, and cornicles yellow-ochre; wings hyaline.

Measurements.—Apterous summer vivipara.—Body 3 to 4 mm.; hind tibiæ 1.8 to 1.9 mm.; hind tarsi .22 mm.; antennæ 1.5 to 1.7 mm.; joint III .48 to .53 mm.; IV .18 to .27 mm.; V .21 to .28 mm.; VI .13 + .17 to .18 mm.; cornicles .25 to .30 mm. Alate vivipara.—Same as aptera, or sometimes with antennal joints slightly longer.

Structural Characters.—Hairs numerous; on antennæ about twice as long as diameter of antennæ. Secondary sensoria small, circular, 20 to 24 in number scattered over entire length of joint III in alate viviparæ; absent in apteræ. Cornicles about twice as long as wide, swollen except at the two ends and with distinct flange. Media twice forked. Lateral tubercles well developed. Rostrum obtuse, attaining between second and third coxæ. Males alate.

Collections.—On bark of twigs of *Salix* and *Populus* sp. Recorded generally throughout the state; fundatrices, April 1 to 29; apterous summer viviparæ, May 5 to Oct. 25; alate viviparæ, May 6 to Oct. 27; oviparæ, Oct. 2 to Nov. 14; males, Oct. 1 to Nov. 3; 54 collections; very common.

SYNONYMICAL NOTES ON MEMBRACIDÆ. II.

FREDERIC W. GODING,
Livermore Falls, Maine.

Owing to the incomplete and occasionally misleading published descriptions of some of Walker's species of the Membracidæ, writers have not been unanimous in their opinions as to the modern genera in which such species belong. His two species of *Centrotus fasciatus* (List Hom. B. M., p. 1147 and id. Suppl., p. 161), *Centrotus opponans* (id. p. 160), *Centrotus oppugnans* (id. p. 160), and *Centrotus humilis* (id. p. 161), were unknown except *C. opponans* which Fowler identified as belonging to the genus *Tolania*. In the description of each species Walker referred to "the hind part" of the pronotum which has been interpreted as referring to the posterior process, whereas it is now known (thanks to Mr. China) that he referred to the scutellum except in one species.

Upon request, Mr. C. E. China kindly examined Walker's types in the British Museum and reports that the type of the *Centrotus fasciatus* first described could not be found, although judging from the description it belongs to the same group, while the types of *C. opponans*, *C. humilis*, and *C. fasciatus* of the Supplement all are destitute of a posterior pronotal process, the tegmina have seven apical cells, the apex of the clavus is acute, and the wings have four apical cells; hence, they belong to *Tolania*. As Walker used the name *fasciatus* for two species in the same genus, *Tolania walkeri* is proposed for the form described in the List Hom. Brit. Mus., Suppl. p. 161.

Mr. China states that the type of *Centrotus oppugnans* is furnished with a posterior pronotal process, the tegmina have five apical cells, the apex of the clavus is acute, and the wings have four apical cells, which characters exclude it from *Tolania*. A comparison of Walker's description and Mr. China's excellent figure of the type (Fig. 1) with Fowler's description of his genus *Centruchoides* and his figure of *C. laticornis* (Fig. 3) leaves no doubt that the two species are congeneric.

From a comparison of the description and figure of Amyot and Serville's lost *Ledra perdita* (Fig. 2) with the descriptions and figures of the two species of *Centruchoides*, it is evident that it also belongs to that genus. It is to be hoped that this study satisfactorily clears up the identity of *perdita*.

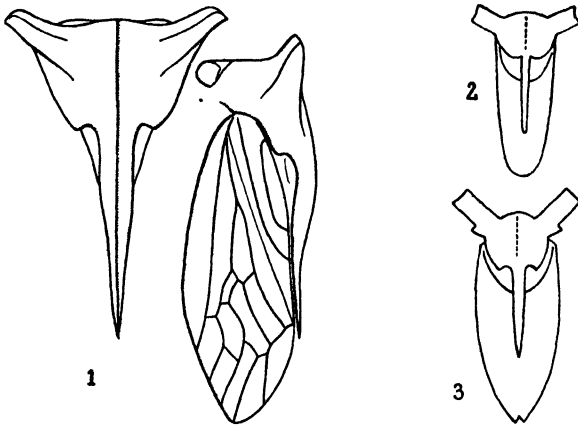


Fig. 1. *Centruchoides oppugnans* Walker, (China, del.).

Fig. 2. *Centruchoides perdita* Amyot and Serville (copied from A. & S.).

Fig. 3. *Centruchoides laticornis* Fowler (copied from Fowler).

A critical review of the genus *Phaulocentrus* Fowler proves it to be distinct from *Microcentrus* Stal, after excluding *P. cornutus* Fowler, which appears to be a true *Microcentrus*.

On page 92 of the Journal of the New York Entomological Society, Vol. XXXVIII, (1930), *Xiphidia* was described as a new genus. As that name was used in the Diptera by Dallas in 1869, and hence preoccupied, *Xiphistoides* is substituted for it.

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